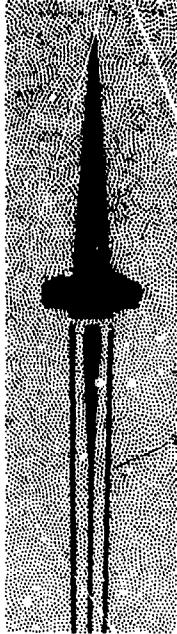


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AND  
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COMMAND**

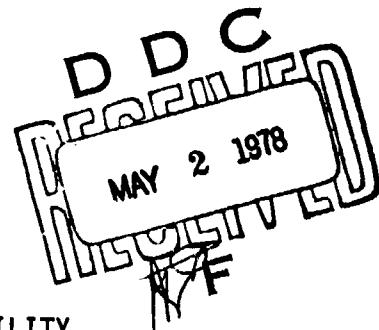
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Redstone Arsenal, Alabama 35809

DM FORM 1000, 1 APR 77

STORAGE RELIABILITY  
OF  
MISSILE MATERIEL PROGRAM



MISSILE MATERIEL RELIABILITY  
PREDICTION HANDBOOK  
PARTS COUNT PREDICTION

LC-78-1

FEBRUARY 1978

PRODUCT ASSURANCE DIRECTORATE

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This handbook contains data for predicting the reliability of missile systems based on a "parts count" approach. The handbook is part of a research program being conducted by the U. S. Army Missile R&D Command, Redstone Arsenal, Alabama. Included is data on electronic, electrical, electromechanical, hydraulic, pneumatic ordnance, and electro optical devices.		392 6/19 ADL	

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Seals, Regulators, Batteries, Ordnance, Rocket Motors, Gas Generators,  
Igniters, Safe & Arm Devices, Optics, Electro Optics, Vidicon Tube,  
Lasers

STORAGE RELIABILITY  
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MISSILE MATERIEL RELIABILITY  
PREDICTION HANDBOOK  
PARTS COUNT PREDICTION

LC-78-1

FEBRUARY 1978

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## ABSTRACT

This handbook contains data for predicting the reliability of missile systems based on a "parts count" approach. The handbook is a result of a program whose objective is the development of non-operating (storage) reliability prediction and assurance techniques for missile materiel. The analysis results will be used by U. S. Army personnel and contractors in evaluating current missile programs and in the design of future missile systems.

The storage reliability research program consists of a country wide data survey and collection effort, accelerated testing, special test programs and development of a non-operating reliability data bank at the U. S. Army Missile R&D Command, Redstone Arsenal, Alabama. The Army plans a continuing effort to maintain the data bank and analysis reports.

Storage or non-operating prediction data contained herein has been developed under the program described above. Operating data has been extracted from existing reliability prediction sources.

For more informations, contact:

Commander

U. S. Army Missile R&D Command

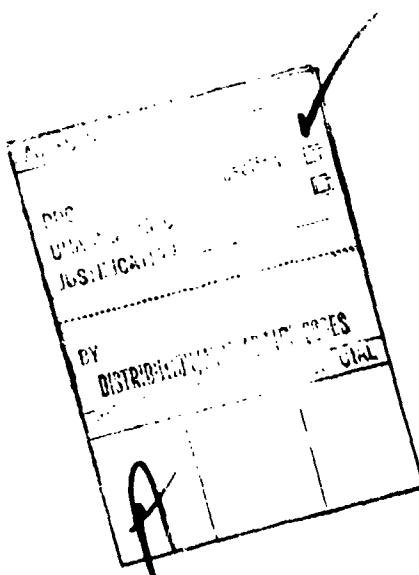
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## TABLE OF CONTENTS

<u>SECTION NO.</u>		<u>PAGE NO.</u>
1.0	INTRODUCTION	1-1
	1.1 Missile Reliability Considerations	1-1
	1.2 Storage Reliability Research Program	1-1
	1.3 Non-Operating Environments	1-2
	1.4 Operating Environments	1-4
	1.5 Limitations of Reliability Prediction	1-4
	1.6 Life Cycle Reliability Prediction Modeling	1-6
	1.7 Data Presentation	1-8
2.0	"PARTS COUNT" PREDICTION DATA	2-1
3.0	FAILURE RATE STATISTICS AND RANGES	3-1
	3.1 Part Category and Description	3-1
	3.2 Non-Operating Data	3-1
	3.3 Electrical and Electronic Operating Data	3-8
	3.4 Non-Electronic Operating Data	3-8
	3.5 Environmental Factors	3-9
	3.6 Quality Factors	3-9
4.0	SAMPLE MISSILE RELIABILITY PREDICTION	4-1
	4.1 Failure Rate Calculations	4-2
	4.1.1 Hybrid Failure Rate Calculations	4-7
	4.1.2 Miscellaneous Failure Rate Calcula- tions	4-8
	4.1.3 Ordnance Reliability	4-9
	4.2 Failure Rate Summation	4-10
	4.3 Missile Five Year Reliability Cal- culation	4-10
	BIBLIOGRAPHY	

TABLE OF CONTENTS (cont'd)

<u>SECTION NO.</u>		<u>PAGE NO.</u>
<b>APPENDIX A - HYBRID MICROELECTRONIC RELIABILITY</b>		
A.1	Non-Operating Reliability	A-1
A.2	Hybrid Integrated Circuits Operational Prediction Model	A-2
	A.2.1 Base Failure Rate $\lambda_b$	A-3
	A.2.2 II Adjustment Factors	A-5
<b>APPENDIX B - ORDNANCE DEVICE RELIABILITY</b>		
B.1	Solid Propellant Rocket Motors	B-1
B.2	Igniter and Safe & Arm Devices	B-3
B.3	Solid Propellant Gas Generators	B-6
B.4	Miscellaneous Ordnance Devices	B-7
<b>APPENDIX C - VACUUM TUBE RELIABILITY</b>		
C.1	Non-Operating Reliability	C-1
C.2	Electronic Vacuum Tube Operational Prediction Model	C-1
<b>APPENDIX D - LASER OPERATIONAL PREDICTION MODELS</b>		
D.1	Laser Operational Prediction Model	D-1
	D.1.1 Helium/Neon Argon Ion Lasers	D-2
	D.1.2 Carbon Dioxide, Sealed Lasers	D-2
	D.1.3 Carbon Dioxide, Flowing Lasers	D-2
	D.1.4 Solid State Nd:YAG Rod Lasers and Ruby Red Lasers	D-3
<b>APPENDIX E - ENVIRONMENTAL FACTORS</b>		

## FIGURES

<u>FIGURE NO.</u>		<u>PAGE NO.</u>
1-1	Storage Reliability Missile Materiel Program Documentation	1-3
4-1	Missile Reliability Block Diagram	4-4
4-2	Reliability Calculation	4-14
A-1	MIL-HDBK-217B Operational Failure Rate Model for Hybrid Microelectronic Devices	A-7
C-1	Electronic Vacuum Tube Non-Operating Failure Rate Models and Parameters	C-2
D-1	MIL-HDBK-217B Operational Failure Rate Model for Helium/Neon Lasers and Argon Ion Lasers	D-5
D-2	MIL-HDBK-217B Operational Failure Rate Model for Carbon Dioxide, Sealed Lasers	D-6
D-3	MIL-HDBK-217B Operational Failure Rate Model for Carbon Dioxide, Flowing Lasers	D-7
D-4	MIL-HDBK-217B Operational Failure Rate Model for Solid State Nd:YAG Rod Lasers and Ruby Red Lasers	D-8
D-5	Examples of Active Optical Surfaces and Count	D-9
D-6	Determination of $\lambda_{PUMP\ HOURS}$ for Neon Flashlamps	D-10
D-7	Determination of $\lambda_{PUMP\ HOURS}$ for Krypton Flashlamps	D-11

TABLES

<u>TABLE NO.</u>		<u>PAGE NO.</u>
1-1	Environmental Description	1-5
2-1	Major Device Groupings	2-2
3-1	Device List	3-2
4-1	Component List	4-3
4-2	Device Failure Rates from Handbook	4-5
4-3	Device Failure Rates for Device Usage	4-11
4-4	System Failure Rates	4-13
4-5	Non-Operating to Operating Failure Rates	4-15
A-1	Hybrid IC Non-Operating Data	A-1
B-1	Propellant Unit Reliability	B-2
B-2	Igniter Reliability Prediction Model	B-4
B-3	Safe & Arm Device Reliability Prediction Model	B-5
B-4	Gas Generator Reliability Prediction	B-6
B-5	Miscellaneous Ordnance Device Failure Rates	B-8
C-1	Base Failure Rate for Tubes	C-3
C-2	Environmental Factor for Tubes	C-3

## 1.0 INTRODUCTION

### 1.1 Missile Reliability Considerations

Materiel in the Army inventory must withstand long periods of storage and "launch ready" non-activated or dormant time as well as perform operationally in severe launch and flight environments. In addition to the stress of temperature soaks and aging, they must often endure the abuse of frequent transportation and handling and the climatic extremes of the forward area battlefield environment.

Missiles spend the majority of the time in this non-operating environment. In newer missile systems, complexity is increasing significantly, longer service lives are being required, and periodic maintenance and checkouts are being reduced. The combination of these factors places great importance on selecting missile materiels which are capable of performing reliably in each of the environments.

The inclusion of storage reliability requirements in the initial system specifications has also placed an importance on maintaining non-operating reliability prediction data for evaluating the design and mechanization of new systems.

### 1.2 Storage Reliability Research Program

An extensive effort is being conducted by the U. S. Army Missile Command to provide detailed analyses of missile materiel and to generate reliability prediction data. This handbook updates LC-76-1 dated May 1976 and provides the current prediction data resulting from this effort.

Non-operating data has been extracted from Report LC-78-2, Storage Reliability Analysis Summary, dated February 1978. LC-78-2 provides a summary of the analyses performed under the storage reliability research program and background information for the predictions in this handbook. Detailed models from which the "parts count" predictions were extracted are presented. Included are summaries of real time and test data, failure modes and mechanisms, and conclusions and recommendations resulting from analysis of the data. These recommendations include special design, packaging and product

assurance data and information on specific part types and part construction.

For a number of the part types, detailed analysis reports are also available. These reports present details on part construction, failure modes and mechanisms, parameter drift and aging trends, applications, and other considerations for the selection of materiel and reliability prediction of missile systems.

The U. S. Army Missile Command also maintains a Storage Reliability Data Bank. This data bank consists of a computerized data base with generic part storage reliability data and a storage reliability report library containing available research and test reports of non-operating reliability research efforts.

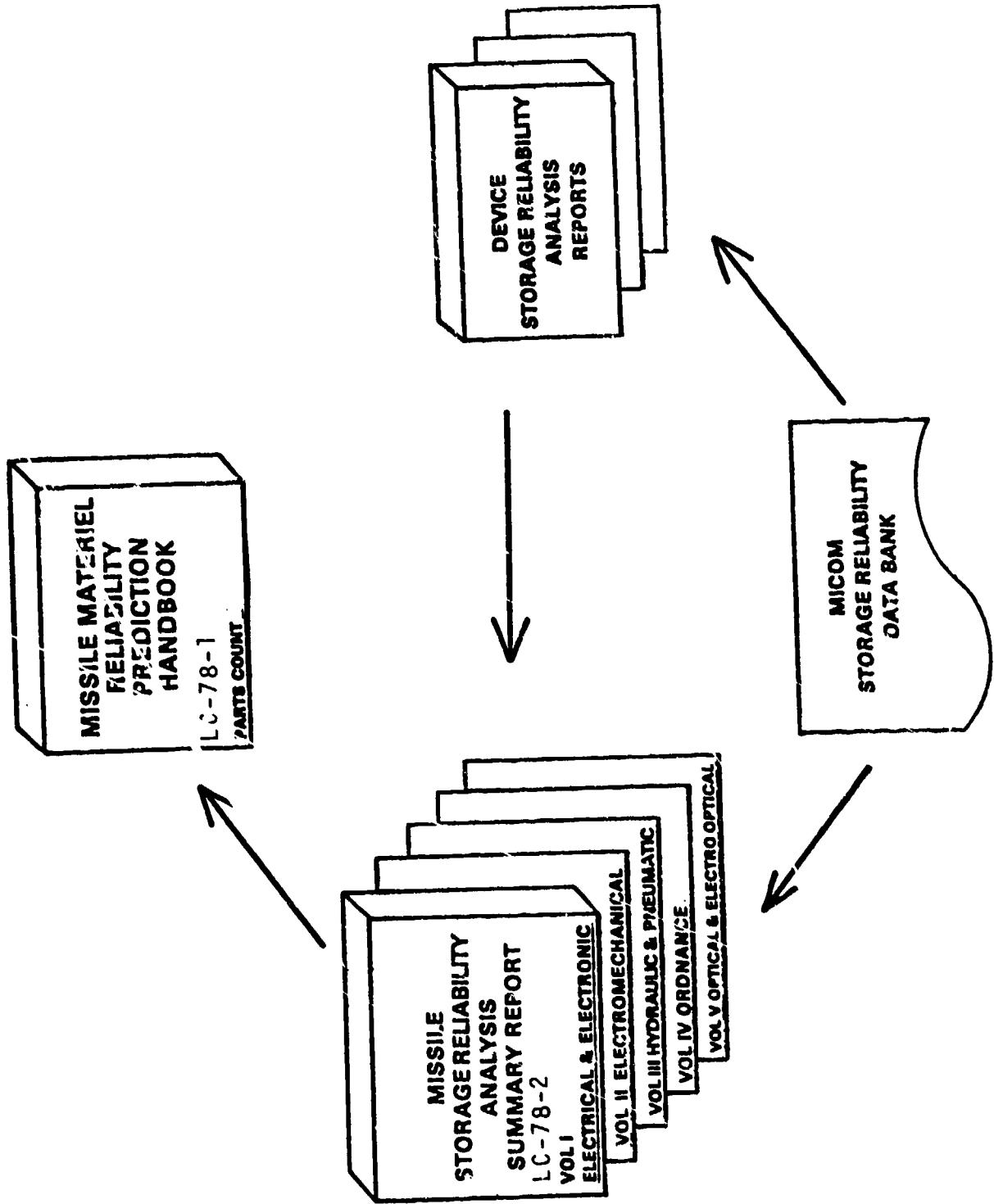
For the operational data contained in this handbook, the user should refer to the following sources: MIL-HDBK-217B, Military Standardization Handbook, Reliability Prediction of Electronic Equipment; Reliability Analysis Center (RAC) Microcircuit Generic Failure Rates; RADC-TR-74-268, Revision to the Nonelectronic Reliability Handbook; and the Government-Industry Data Exchange Program (GIDEP) Summaries of Failure Rate Data.

### 1.3 Non-Operating Environments

A missile system may be subjected to various modes of transportation and handling, temperature soaks, climatic extremes, and activated test time and "launch ready" time in addition to a controlled storage environment. Some studies have been performed on missile systems to measure these environments. A summary of several studies is presented in Report BR-7811, "The Environmental Conditions Experienced by Rockets and Missiles in Storage, Transit and Operations" prepared by the Raytheon Company, dated December 1973.

In this report, skin temperatures of missiles in containers were recorded in dump (or open) storage at a maximum of 165°F (74°C) and a minimum of -44°F (-42°C). In non-earth

FIGURE 1-1. STORAGE RELIABILITY OF  
MISSILE MATERIEL PROGRAM DOCUMENTATION



covered bunkers temperatures have been measured at a maximum of 116°F (47°C) to a minimum of -31°F (-35°C). In earth covered bunkers, temperatures have been measured at a maximum of 103°F (39°C) to a minimum of 23°F (-5°C).

Acceleration extremes during transportation have been measured for track, rail, aircraft and ship transportation. Up to 7 G's at 300 hertz have been measured on trucks; 1 G at 300 hertz by rail; 7 G's at 1100 hertz on aircraft; and 1 G at 70 hertz on shipboard.

Maximum shock stresses for truck transportation have been measured at 10 G's and by rail at 300 G's.

Although field data does not record these levels, where available, the type and approximate character of storage and transportation conditions are identified and used to classify the devices in LC-78-2.

The ground, fixed non-operating environment represents the bulk of the non-operating data and is reported in this handbook. A continuing effort is planned to attempt to differentiate between other non-operating environments. Appendix E presents the MIL-HDBK-217B Environmental Factors.

#### 1.4 Operating Environments

The operational data contains two sets of environments. The first set has been extracted from MIL-HDBK-217B and each environment is described in Table 1-1.

The second set has been extracted from document RADC-TR-74-268, Section 2, "Revision to RADC Nonelectronic Reliability Notebook," dated October 1974. This set is only slightly different from the MIL-HDBK-217B environments.

#### 1.5 Limitations of Reliability Prediction

Practical limitations are placed in any reliability analysis effort in gathering and analyzing data. Field data is generated at various levels of detail and reported in varying manners. Often data on environments, applications, part classes and part construction are not available. Even more often, failure analyses are non-existent. Data on low use devices and new technology devices is also difficult to

TABLE 1-1.  
ENVIRONMENTAL DESCRIPTION

<u>Environment</u>	<u>Nominal Environmental Conditions</u>
Ground, Benign	Nearly zero environmental stress with optimum engineering operation and maintenance.
Space, Flight	Earth orbital. Approaches Ground, Benign conditions without access for maintenance. Vehicle neither under powered flight nor in atmospheric re-entry.
Ground, Fixed	Conditions less than ideal to include installation in permanent racks with adequate cooling air, maintenance by military personnel and possible installation in unheated buildings.
Ground, Mobile (and Portable)	Conditions more severe than those for Ground, Fixed, mostly for vibration and shock. Cooling air supply may also be more limited, and maintenance less uniform.
Naval, Sheltered	Surface ship conditions similar to Ground, Fixed, subject to occasional high shock and vibration.
Naval, Un- sheltered	Nominal surface shipborne conditions but with repetitive high levels of shock and vibration.
Airborne, Inhabited	Typical cockpit conditions without environmental extremes of pressure, temperature, shock and vibration.
Airborne, Uninhabited	Bomb-bay, tail, or wing installations where extreme pressure, temperature, and vibration cycling may be aggravated by contamination from oil, hydraulic fluid, and engine exhaust. Classes I and Ia equipment of MIL-E-5400 should not be used in this environment.
Missile, Launch	Severe conditions of noise, vibration, and other environments related to missile launch, and space vehicle boost into orbit, vehicle re-entry and landing by parachute. Conditions may also apply to installation near main rocket engines during launch operations.

obtain. Finally in the storage environment, the very low occurrence of failures in many devices requires extensive storage time to generate any meaningful statistics.

These difficulties sometimes lead to prediction of conservative or pessimistic failure rates. The user may review the existing data in the backup analyses reports in any case where design or program decision is necessary.

#### 1.6 Life Cycle Reliability Prediction Modeling

Developing missile reliability predictions requires several tasks. The first tasks include defining the system, its mission, environments and life cycle operation or deployment scenario.

The system and mission definitions provide the basis for constructing reliability success models. The modeling can incorporate reliability block diagrams, truth tables and logic diagrams. Descriptions of these methods are not included here but are discussed in detail in MIL-HDBK-217B or other texts listed in the bibliography.

After the reliability success modeling is completed, reliability life cycle prediction modeling for each block or unit in the success model is performed based on the definitions of the system environment and deployment scenario. This reliability life cycle modeling is based on a "wooden round" concept in order to assess the missile's capability of performing in a no-maintenance environment. The general equation for this modeling is:

$$R_{LC} = R_{T/H} \times R_{STOR} \times R_{TEST} \times R_{LR/D} \times R_{LR/O} \times R_L \times R_F$$

where:

$R_{LC}$  is the unit's life cycle reliability

$R_{T/H}$  is the unit's reliability during handling and transportation

$R_{STOR}$  is the reliability during storage

$R_{TEST}$  is the unit's reliability during check out and test

$R_{LR/D}$  is the unit's reliability during dormant launch ready time

$R_{LR/O}$  is the unit's reliability during operational (>10% electronic stress) launch ready time

$R_L$  is the unit's reliability during powered launch and flight

$R_F$  is the unit's reliability during unpowered flight

The extent of the data to date does not provide a capability of separately estimating the reliability of transportation and storage for missile materiel. Also data has indicated no difference between dormant (>0 and <10% electrical stress) and non-operating time. Therefore, the general equation can be simplified as follows:

$$R_{LC}(t) = R_{NO}(t_{NO}) \times R_O(t_O) \times R_L(t_L) \times R_F(t_F)$$

where:

$R_{NO}$  is the unit's reliability during transportation and handling, storage and dormant time (non-operating time)

$t_{NO}$  is the sum of all non-operating and dormant time

$R_O$  is the unit's reliability during checkout, test or system exercise during which components have electrical power applied (operating)

$t_O$  is the sum of all operating time excluding launch and flight

$R_L$  is the unit's reliability during powered launch and flight (Propulsion System Active)

$t_L$  is the powered launch and flight time

$R_F$  is the unit's reliability during unpowered flight

$t_F$  is the unpowered flight time

$t$  is the sum of  $t_{NO}$ ,  $t_O$ ,  $t_L$  and  $t_F$

The values  $R_{NO}$ ,  $R_O$ ,  $R_L$ , and  $R_F$  are calculated using several methods. The primary method is to assume exponential distributions as follows:

$$\begin{aligned}R_{NO}(t_{NO}) &= e^{-\lambda_{NO} t_{NO}} \\R_O(t_O) &= e^{-\lambda_O t_O} \\R_L(t_L) &= e^{-\lambda_L t_L} \\R_F(t_F) &= e^{-\lambda_F t_F}\end{aligned}$$

The failure rates  $\lambda_{NO}$ ,  $\lambda_O$ ,  $\lambda_L$  and  $\lambda_F$  are calculated from the information in the following sections. Failures rates are given for various environments and quality levels and are based on part stress factors which may include complexity, construction, derating, and other characteristics of the device.

Other methods for calculating the reliability include wearout or aging reliability models and cyclic or one shot reliability models. For each of these cases, the device section will specify the method for calculating the reliability.

#### 1.7 Data Presentation

The data is presented in two formats. Section 2.0 lists failure rates for individual part types. Failure rates are given for the non-operating environment and a number of operating environments.

Section 3.0 provides backup information on these failure rates. It includes part hours and number of failures (where available) used to generate the failure rates; 90% one-sided confidence limits; failure rate ranges where available; and environment and quality adjustment factors.

Finally Section 4.0 provides an example reliability prediction of a missile system using the data.

## 2.0 "PARTS COUNT" PREDICTION DATA

Non-operating and operating failure rates are presented in the following pages for electronic, electrical, electro-mechanical, hydraulic, pneumatic, and ordnance devices. Failure rates are given in FITS, failures per billion hours.

These failure rates represent recorded failures which in most cases have been attributed to a defect or wear out of the part itself. Secondary failures resulting from mishandling, system design or test equipment problems are not included in the failure rates.

Table 2-1 lists the major device groupings and the page on which they are presented.

The failure rates presented assume an exponential failure distribution and are averages for the stated environments. In some cases, the failure rate is broken out by quality level and complexity. In other cases, it is the average for a range of quality levels and complexities.

Quality levels include MIL-STD-883, Class A, B and C levels for microelectronics; MIL-S-19500, JAN, JANTX and JANTXV levels for discrete semiconductors; and other device quality levels as defined in the applicable military reference.

Prediction data for four device types (Hybrid Microelectronics, Vacuum Tubes, Ordnance and Laser devices) are presented in the Appendices. In the case of Hybrid Microelectronics and Lasers, the diversity of parts does not allow a simple "parts count" prediction. In the case of vacuum tubes and ordnance devices, the exponential failure distribution does not apply in all cases.

TABLE 2-1. MAJOR DEVICE GROUPINGS

<u>GROUP</u>	<u>PAGE NO.</u>
Monolithic Microelectronic Devices	2-3
Hybrid Microelectronic Devices	2-5
Discrete Semiconductors	2-6
Tubes, Electronic Vacuum	2-9
Resistors	2-10
Capacitors	2-14
Inductive Devices	2-17
Misc. Electrical & Electronic	2-18
Electromechanical	2-19
Hydraulic and Pneumatic	2-22
Ordnance	2-28
Optical & Electro-optical	2-29

## MONOLITHIC MICROELECTRONIC DEVICES

PART TYPE	STORAGE FAILURE RATE IN FITS	OPERATIONAL FAILURE RATE IN FITS						MISSILE LAUNCH	
		GROUND BENIGN	SPACE FLIGHT	GROUND FIXED	AIR-BORNE INHAB.	NAVAL SHEL.	GROUND MOBILE	NAVAL UNSHEL	
<u>BIPOLAR DIGITAL (TTL &amp; DTL)</u>									
1-20 Gates	0.85	3.5	3.5	14.5	45.5	46.5	45.5	70.0	105.
Class A	3.30	7.0	7.0	29.0	91.0	93.0	91.0	120.	210.
Class B	3.73	56.0	56.0	232.	728.	744.	728.	960.	1680.
21-50 Gates	0.85	10.0	10.0	31.0	80.0	85.0	80.0	115.	170.
Class A	3.30	20.0	20.0	62.0	160.	170.	166.	230.	340.
Class B	3.73	160.	160.	496.	1280.	1360.	1280.	1840.	2720.
50-100 Gates	0.85	16.0	16.0	47.0	115.	120.	115.	170.	235.
Class A	3.30	32.0	32.0	94.0	230.	240.	230.	340.	470.
Class B	3.73	256.	256.	752.	1840.	1920.	1840.	2720.	3760.
<u>BIPOLAR LINEAR</u>									
<32 Trans.	0.85	6.0	6.0	26.0	75.0	80.	75.0	135.	165.
Class A	3.30	12.0	12.0	52.0	150.	160.	150.	270.	330.
Class B	3.73	96.0	96.0	416.	1200.	1280.	1200.	2160.	2640.
33-100 Trans.	0.85	20.8	20.8	96.	256.	280.	256.	480.	488.
Class A	3.30	26.0	26.0	120.	320.	350.	320.	600.	680.
Class B	3.73	208.	208.	960.	2560.	2800.	2560.	4800.	4880.
<u>BIPOLAR MEMORIES &lt;1000 bits</u>									
Class A	-	60.0	60.0	150.	305.	335.	305.	490.	495.
Class B	-	120.0	120.0	300.	610.	670.	610.	980.	990.
Class C	-	960.	960.	2400.	4880.	5360.	4880.	7840.	7920.
1001-4000 bits	-	130.	130.	350.	700.	750.	700.	1150.	1150.
Class A	-	260.	260.	700.	1400.	1500.	1400.	2300.	2300.
Class B	-	2080.	2080.	5600.	11200.	12000.	11200.	18400.	18400.
Class C	-								20800.

MONOLITHIC MICROELECTRONIC DEVICES (cont'd)

PART TYPE	STORAGE FAILURE RATE IN FITS	OPERATIONAL FAILURE RATE IN FITS						MISSILE LAUNCH
		GROUND BENIGN	SPACE FLIGHT	GROUND FIXED	AIR-BORNE INHAB.	NAVAL SHEL.	GROUND MOBILE	NAVAL UNSHEL
<b>BIPOLAR MEMORIES</b>								
4001-8000 bits	-	220.	220.	600.	1200.	1300.	1200.	1950.
Class A	-	440.	440.	1200.	2400.	2600.	2400.	2250.
Class B	-	3520.	3520.	9600.	19200.	20800.	19200.	4500.
Class C	-							36000.
<b>MOS DEVICES</b>								
1-20 Gates	-	5.	5.	24.	60.	70.	60.	120.
Class A	-	10.	10.	48.	120.	140.	120.	240.
Class B	-	80.	80.	384.	960.	1120.	960.	1920.
Class C	-							
21-50 Gates	-	24.	24.	95.	170.	215.	170.	460.
Class A	-	48.	48.	190.	340.	430.	340.	395.
Class B	-	384.	384.	1520.	2720.	3440.	2720.	790.
Class C	-							6320.
51-100 Gates	-	38.	38.	155.	270.	340.	270.	750.
Class A	-	76.	76.	310.	540.	680.	540.	1500.
Class B	-	608.	608.	2480.	4320.	5440.	4320.	12000.
Class C	-							10400.
<b>MOS MEMORIES</b>								
<1000 bits	-	160.	160.	600.	950.	1200.	950.	2850.
Class A	-	320.	320.	1200.	1900.	2400.	1900.	5700.
Class B	-	2560.	2560.	9600.	15200.	19200.	15200.	45600.
Class C	-							37600.
1001-4000 bits	-	350.	350.	1350.	2150.	2800.	2150.	6500.
Class A	-	700.	700.	2700.	4300.	5600.	4300.	13000.
Class B	-	5600.	5600.	21600.	34400.	44800.	34400.	104000.
Class C	-							88000.
4001-8000 bits	-	600.	600.	2250.	3600.	4700.	3600.	11000.
Class A	-	1200.	1200.	4500.	7200.	9400.	7200.	22000.
Class B	-	9600.	9600.	36000.	57600.	752000.	57600.	176000.
Class C	-							144000.

## HYBRID MICROELECTRONIC DEVICES

PART TYPE	STORAGE FAILURE RATE IN FITS	OPERATIONAL FAILURE RATE IN FITS								
		GROUND BENIGN	SPACE FLIGHT	GROUND FIXED	AIR-INHAB.	NAVAL SHEL.	GROUND MOBILE	AIR-UNSHIEL	NAVAL UNINHAB	AIR-BORNE
SEE APPENDIX "A"										

## DISCRETE SEMICONDUCTORS - TRANSISTORS

PART TYPE	STORAGE FAILURE RATE IN FITS	OPERATIONAL FAILURE RATE IN FITS						MISSILE LAUNCH
		GROUND BENIGN	SPACE FLIGHT	GROUND FIXED	AIR-BORNE INHAB.	NAVAL SHELL	GROUND MOBILE	NAVAL UNSHELLED
SILICON NPN								
JANTX	1.51	5.6	5.6	36.	196.	220.	196.	400.
JAN	8.82	28.	28.	180.	980.	1100.	980.	2000.
SILICON PNP								
JANTX	1.51	8.4	8.4	58.	320.	340.	320.	640.
JAN	8.82	42.	42.	290.	1600.	1700.	1600.	2300.
GERMANIUM PNP								
JANTX	1.51	8.4	8.4	82.	520.	700.	520.	500.
JAN	8.82	42.	42.	410.	2600.	3500.	2600.	3200.
GERMANIUM NPN								
JANTX	1.51	24.	24.	220.	1420.	1800.	1420.	520.
JAN	8.82	120.	120.	1100.	7100.	9000.	7100.	2600.
FIELD EFFECT								
JANTX	1.15	15.2	15.2	104.	540.	580.	540.	840.
JAN	5.75	76.	76.	520.	2700.	2900.	2700.	4200.
UNIJUNCTION								
JANTX	388.	50.	50.	340.	1880.	2000.	1880.	1120.
JAN	776.	250.	250.	1700.	9400.	10000.	9400.	5600.
MICROWAVE								
JANTX	58.8	240.	240.	480.	2400.	2400.	2400.	3840.
JAN	117.6	480.	480.	960	4800.	4800.	4800.	7680.

\*This value valid only for electrical stress,  $S \leq 0.3$ .

## DISCRETE SEMICONDUCTORS - DIODES

PART TYPE	STORAGE FAILURE RATE IN FITS	OPERATIONAL FAILURE RATE IN FITS				MISSILE LAUNCH
		GROUND BENIGN	SPACE FLIGHT	GROUND FIXED	AIR-BORNE INHAB.	
<u>SILICON GENERAL PURPOSE</u>						
JANTX	.29	3.4	3.4	24.	136.	220.
JAN	6.25	17.	17.	120.	680.	1100.
<u>GERMANIUM GENERAL PURPOSE</u>						
JANTX	.29	4.4	4.4	52.	340.	500*
JAN	6.25	22.	22.	260.	1700.	2500*
<u>ZENER &amp; AVALANCHE</u>						
JANTX	1.56	5.4	5.4	32.	170.	240.
JAN	1.56	27.	27.	160.	910.	1200.
<u>THYRISTORS</u>						
JANTX	5.0	4.6	4.6	32.	180.	280.
JAN	25.0	23.	23.	160.	900.	1400.
<u>SILICON MICROWAVE DETECTOR</u>						
JANTX	14.7	114.	114.	1320.	7200.	10200.
JAN	24.5	190.	190.	2200.	12000.	17000.
<u>GERMANIUM MICRO-WAVE DETECTOR</u>						
JANTX	14.7	246.	246.	3360*	21000*	21000*
JAN	24.5	410.	410.	5600*	35000*	35000*
<u>SILICON MICROWAVE MIXER</u>						
JANTX	14.7	150.	150.	1800.	12800.	12800.
JAN	24.5	250.	250.	3000.	16000.	16000.

\*This value valid only for electrical stress,  $S \leq 0.3$ .

\*\*Not to be used in these environments.

## DISCRETE SEMICONDUCTORS - DIODES (cont'd)

PART TYPE	STORAGE FAILURE RATE IN FITS	OPERATIONAL FAILURE RATE IN FITS						MISSILE LAUNCH
		GROUND BENIGN	SPACE FLIGHT	GROUND FIXED	AIR-BORNE INHAB.	NAVAL SHELL.	GROUND MOBILE UNSHEL.	
<u>GERMANIUM MICRO-WAVE MIXER</u>								
JANTX	14.7	432.	432.	6000:	36600:	**	36600:	**
JAN	24.5	720.	720.	10000:	61000:	**	61000:	**
<u>VARACTORS, STEP RECOVERY &amp; TUNNEL</u>								
JANTX	1.05.	48.	48.	300.	1620.	1760.	3400.	2400.
JAN	523.	240.	240.	1500.	6100.	8800.	17000.	12000.
<u>SILICON CONTROLLED RECTIFIERS</u>								
JANTX	1.96	5.1	5.1	36.	204.	225.	204.	330.
JAN	9.8	26.	26.	180.	1020.	1125.	1020.	1650.

\* This value valid only for electrical stress,  $S \leq 0.3$ .  
 \*\* Not to be used in these environments.

## TUBES, ELECTRONIC VACUUM

PART TYPE	STORAGE FAILURE RATE IN FITS	OPERATIONAL FAILURE RATE IN FITS						MISSILE LAUNCH
		GROUND BENIGN	SPACE FLIGHT	GROUND FIXED	AIR-BORNE INHAB.	NAVAL SHEL.	GROUND MOBILE	
<u>RECEIVER TUBES</u>								
Tetrode, Triode, Pentode	12.0	2500	2500	5000	32500	32500	50000	50000 400000
Power Rectifier	12.0	5000	5000	10000	65000	65000	100000	100000 600000
<u>KLYSTRON</u>								
Low Power	See Appendix C	15000	15000	30000	195000	195000	300000	300000 2400000
High Power		100000	100000	200000	300000	300000	2000000	2000000 16000000
<u>MAGNETRON</u>								
Medium Power	See Appendix C	100000	100000	200000	1300000	1300000	2000000	2000000 16000000
High Power		225000	225000	450000	2925000	2925000	4500000	4500000 3600000
<u>TWT</u>								
Peak Power <100 watts	See Appendix C	15000	15000	30000	195000	195000	300000	300000 2400000
Peak Power >100 watts <10,000 watts		50000	50000	100000	650000	650000	1000000	1000000 800000
<u>TRANSMITTING</u>								
Triode	TBD	37500	75000	488000	488000	750000	750000	750000 600000
Tetrode & Pentode	TBD	50000	50000	100000	650000	650000	1000000	1000000 800000

## RESISTORS

PART TYPE	STORAGE FAILURE RATE IN FITS	OPERATIONAL FAILURE RATE IN FITS						MISSILE LAUNCH	
		GROUND BENIGN	SPACE FLIGHT	GROUND FIXED	AIR-BORNE INHAB.	NAVAL SHEL.	GROUND MOBILE	NAVAL UNSHEL	
<u>FIXED COMPOSITION (Insulated)</u>									
MIL-R-39008	<.066	.45	.45	2.	4.8	7.7	8.5	21.	18.
Style RCR									
Hi-Rel									
MIL-R-11									
Style RC									
MIL-STD	.22	2.3	2.3	10.	24.	39.	43.	110.	90.
<u>FIXED FILM (Insulated)</u>									
MIL-R-39017									
Style RLR									
Hi-Rel									
MIL-STD	.017	2.4	2.4	15.	20.	26.	37.	52.	54.
MIL-R-22684									
Style RLC									
MIL-STD	0.11	13.	13.	75.	100.	130.	190.	260.	270.
<u>FIXED FILM</u>									
MIL-R-55182									
Style RNR, RNC									
Hi-Rel									
MIL-R-10509	.017	.28	.28	1.7	2.3	3.	4.2	6.2	6.3
Style RN									
MIL-STD	<.11	2.8	2.8	17.	23.	30.	42.	62.	63.
<u>POWER FILM</u>									
MIL-R-11804									
Style RD/P									
MIL-STD	TBD	180.	180.	960.	1300.	1500.	2300.	2800.	3100.
									6800.

## RESISTORS (cont'd)

PART TYPE	STORAGE FAILURE RATE IN FITS	GROUND BENIGN	SPACE FLIGHT	GROUNDFIXED	OPERATIONAL FAILURE RATE IN FITS			NAVAL UNSHIEL	AIRBORNE UNINHAB	MISSILE LAUNCH
					AIRBORNE INHAB.	NAVAL SHEL.	GROUND MOBILE			
<u>FIXED WIREWOUND ACCURATE</u>										
MIL-R-39005 Style RBR Hi-Rel	.20	8.5	8.5	56.	150.	180.	190.	260.	320.	680.
MIL-R-93 Style RB MIL-STD	1.19	43.	43.	280.	750.	900.	950.	1300.	1600.	3400.
<u>FIXED WIREWOUND POWER TYPE</u>										
MIL-R-39007 Style RWR Hi-Rel	.20	9.	9.	33.	66.	85.	110.	160.	260.	330.
MIL-R-26 Style RW MIL-STD	1.19	46.	46.	170.	330.	430.	550.	800.	1300.	1700.
<u>FIXED WIREWOUND POWER TYPE CHASSIS MOUNTED</u>										
MIL-R-39009 Style RER Hi-Rel	.20	16.	16.	62.	130.	160.	220.	300.	340.	660.
MIL-R-18546 Style RE MIL-STD	1.19	80.	80.	310.	650.	800.	1100.	1500.	1700.	3300.
<u>THERMISTOR</u>										
MIL-T-23648 Hi-Rel MIL-STD	<16.9 133.3	21.	21.	100.	250.	300.	520.	400.	340.	1200.

## RESISTORS (cont'd)

PART TYPE	STORAGE FAILURE RATE IN FITS	OPERATIONAL FAILURE RATE IN FITS						MISSILE LAUNCH		
		GROUND BENIGN	SPACE FLIGHT	GROUND FIXED	AIR-BORNE INHAB.	NAVAL SHELL.	GROUND MOBILE	NAVAL UNSHEL		
<u>VARIABLE WIREWOUND LEADSCREW ACTUATED</u>										
MIL-R-39015 Style RTR Hi-Re1	3.71	18.	18.	66.	140.	170.	180.	340.	300.	1400.
MIL-R-27208 Style RT MIL-STD	3.79	90.	90.	*	700.	850.	900.	1500.	1700.	9000.
<u>WIREWOUND POTENTIOMETERS</u>										
Precision MIL-R-12934 Style RR	<8.4	430.	430.	2700.	5800.	6100.	5800.	9000.	11000.	70000.
MIL-STD Semiprecision MIL-R-19 Style RA & MIL-R-39002 Style RK	*	*	*	*	*	*	*	*	*	*
MIL-STD Power MIL-R-22 Style RP	<8.4	260.	*	2300.	6400.	8600.	8500.	*	*	*
MIL-STD	<8.4	290.	*	2300.	6000.	7500.	8100.	*	*	*

PART TYPE	STORAGE FAILURE RATE IN FITS	RESISTORS (cont'd)						MISSILE LAUNCH	
		GROUND BENIGN	SPACE FLIGHT	GROUND FIXED	AIR-BORNE INHAB.	NAVAL SHELL.	GROUND MOBILE	NAVAL UNSHEL.	
<u>VARIABLE (NON-WIREWOUND TRIMMER)</u>									
MIL-R-39035 Style RJR Hi-ReI	3.71	650.	*	2300.	4750.	6500.	8000.	11500.	13500.
MIL-R-22097 Style RJ MIL-STD	<8.4	1300.	*	4600.	9500.	13000.	16000.	23000.	27000.
<u>COMPOSITION (LOW-PRECISION) POTENTIOMETERS</u>									
MIL-14 STY RV MIL-STD	<8.4	270.	*	3700.	20000.	22000.	20000.	34000.	34000.
TIN OXIDE NETWORK	<2.1								
	<909.1								

## CAPACITORS

PART TYPE	STORAGE FAILURE RATE IN FITS	OPERATIONAL FAILURE RATE IN FITS						MISSILE LAUNCH
		GROUND BENIGN FLIGHT	SPACE FLIGHT	GROUND FIXED	AIR-BORNE INHAB.	NAVAL SHELL.	GROUND MOBILE	NAVAL UNSHEL.
<u>PAPER &amp; PLASTIC FILM</u>								
MIL-C-39022 Style CHR;								
MIL-C-14157 Style CPV;								
MIL-C-19978 Style CQR								
Hi-Rel	.11	.2	.2	.6	1.2	1.6	1.2	9.
MIL-C-19978 Style CQ MIL-STD	4.1	2.	2.	6.	12.	16.	12.	120.
<u>MICA</u>								
MIL-C-39001 Style CMR								
Hi-Rel	.61	.3	.3	3.2	6.0	7.8	6.0	34.
MIL-C-5 Style CM MIL-STD	.61	3.	3.	32.	60.	78.	60.	340.
MIL-C-10950 Style CB MIL-STD	.61	120.	120.	580.	930.	990.	930.	3700.
<u>GLASS</u>								
MIL-C-23269 Style CYR								
Hi-Rel	.63	1.3	1.3	11.	21.	25.	21.	110.
								160.
								110.

## CAPACITORS (cont'd)

PART TYPE	STORAGE FAILURE RATE IN FITS	GROUND BENIGN FITS	SPACE FLIGHT	GROUND FIXED	OPERATIONAL FAILURE RATE IN FITS			MISSILE LAUNCH
					AIR-BORNE INHAB.	NAVAL SHEL.	GROUND NAVAL MOBILE UNSHEL.	
<u>CERAMIC</u>								
MIL-C-20 Style CCR MIL-C-39014 Style CKR Hi-Rel	.32	10.	10.	22.	44.	44.	96.	110. 170.
MIL-C-20 Style CC MIL-C-11015 Style CK MIL-STD	2.14	100.	100.	220.	440.	440.	960.	1100. 1700.
<u>TANTALUM ELECTROLYTIC (SOLID)</u>								
MIL-C-39003 Style CSR Hi-Rel	.13	11.	11.	26.	52.	56.	170.	260. 260.
<u>TANTALUM ELECTROLYTIC (NON-SOLID)</u>								
MIL-C-39006 Style CLR Hi-Rel	9.0	15.	15.	34.	110.	110.	340.	440. 440.
MIL-C-3965 Style CL MIL-STD	12.5	150.	150.	340.	1100.	1100.	3400.	4400. 4400.
<u>ALUMINUM OXIDE</u>								
MIL-C-39018 Style CU MIL-STD	<6.46	73.	73.	230.	1600.	1900.	5300.	6900. 5400.

## CAPACITORS (cont'd)

PART TYPE	STORAGE FAILURE RATE IN FITS	OPERATIONAL FAILURE RATE IN FITS						MISSILE LAUNCH	
		GROUND BENIGN	SPACE FLIGHT	GROUND FIXED	AIR-BORNE INHAB.	NAVAL SHEL.	GROUND MOBILE	NAVAL UNSHEL	
ALUMINUM DRY ELECTROLYTIC									
MIL-C-62 Style CE MIL-STD	TBD	110.	110.	410.	3000.	3800	3000	14000.	16000.
VARIABLE, CERAMIC									
MIL-C-81 Style CV MIL-STD	TBD	200.	200.	1100.	2400.	2700	2400	12000.	22000.
VARIABLE, PISTON TYPE									
MIL-C-14409 Style PC MIL-STD	<6.46	16.	16.	110.	410.	470	410.	3800.	5300.
TITANIUM	<19.6								
TUBULAR, TEMP.	<78.1								
DIFFERENTIAL, DUAL MODE	<15.7								
METALLIZED POLY-CARBONITE	18.5								
VARIABLE, AIR NETWORK	35.6 <909.1								

INDUCTIVE DEVICES		OPERATIONAL FAILURE RATE IN FITS								
PART TYPE	STORAGE FAILURE RATE IN FITS	GROUND BENIGN	SPACE FLIGHT	GROUND FIXED	AIR-BORNE INHAB.	NAVAL SHEL.	GROUND MOBILE	NAVAL UNSHEL	AIR-BORNE UNINHAB	MISSILE LAUNCH
<u>TRANSFORMERS &amp; INDUCTORS</u>										
MIL-T-39013 Hi-Rel	.91	1.25	1.25	3.3	9.	10.	5.5	13.5	17.	18.
MIL-T-27 MIL-STD	13.9	2.5	2.5	6.6	18.	20.	11.	27.	14.	36.
<u>COILS, RADIO FREQUENCY</u>										
MIL-C-15305 Hi-Rel	1.11	4.8	4.8	11.	30.	33.	18.	42.	55.	60.
MIL-STD	<1.34	9.6	9.6	22.	60.	66.	36.	84.	110.	120.
<u>TRANSFORMERS PULSE, LOW POWER</u>										
MIL-T-39026 Hi-Rel	.91	.79	.79	1.78	4.95	5.48	2.97	7.26	9.24	9.9
MIL-T-21038 MIL-STD	13.9	1.2	1.2	2.7	7.5	8.3	4.5	11.	14.	15.
<u>FILTERS &amp; CHOKES</u>										
Hi-Rel	.55	3.75	3.75	11.	28.	32.	17.	48.	60.	55.
MIL-STD	9.62	7.5	7.5	21.	56.	64.	34.	96.	120.	110.
<u>REACTORS</u>										
Hi-Rel	3.12									
MIL-STD	<76.9									

## MISCELLANEOUS ELECTRICAL AND ELECTRONIC DEVICES

PART TYPE	STORAGE FAILURE RATE IN FITS	OPERATIONAL FAILURE RATE IN FITS						HELI-COPTER
		SATELLITE	GROUND	AIR-BORNE	MISSILE	SHIP-BOARD	SUB-MARINE	
<u>CRYSTALS</u>	39.3	200.						
<u>PRINTED WIRING BOARD</u>	.67	1.5	2.4	4.8	7.2	24.	12.0	4.8
<u>CONNECTIONS &amp; CONNECTORS</u>								
Pin Connector	.012		.6					
Solder Connection	<0.028		3.9					
Weld Connection	<0.18		1.7					
Wrap Connection	TBD		.014					
<u>INSTRUMENTS</u>	94.7	3000000		756	179215		17094	238000
<u>FUSES</u>	<213.		100					
<u>HEATERS</u>	<385.		1000					
<u>MAGNETIC CORE</u>	<.028							
<u>SOLAR CELLS</u>	10.7							
<u>SENSOR, TEMP.</u>	<476.		2413	21964	97193		285714	161572
<u>LAMPS</u>	37.9			200				

## ELECTROMECHANICAL DEVICES

PART TYPE	STORAGE FAILURE RATE IN FITS	OPERATIONAL FAILURE RATE IN FITS						HELI-COPTER
		SATELLITE	GROUND	GROUND MOBILE	AIR-BORNE	MISSILE	SHIP-BOARD	
<u>ACCELEROMETER</u>								
General	29.7	<8929.	52523.	<27027.	236585			
<u>GYROSCOPE</u>								
Rate	133.		26005.	333333.	371772	541667		254902
<u>RELAY</u>								
General	8.5	8.4	166.	6743		754.	1278.	62031
Armature	8.5		233.	1229	1951		916.	1030.
Crystal Can, Latching	8.5			21277.				
Latching, General	8.5	<269.	569.				342.	
Reed	8.5			184.			1973.	
Thermal	8.5			13089.			746.	
Time Delay	8.5			1446.	4246.	17254.	1599.	674.

**ELECTROMECHANICAL DEVICES**

PART TYPE	STORAGE FAILURE RATE IN FITS	OPERATIONAL FAILURE RATE IN FITS						SUB-MARINE	HELICOPTER
		SATELLITE	GROUND	MOBILE	AIR-BORNE	MISSILE	SHIP-BOARD		
<u>SWITCH</u>									
General	82.8	508.	<742.	6112.	107004		22556	506.	98639.
Pressure	54.2		2095.	56027			458	6525.	332378.
Pushbutton	26.0		271.	27870			1536	78.	<778.
Rotary	82.8	418.	1329.		17695			1584.	21739.
Sensitive	82.8		1133.		14650	250000		1110.	4918.
Thermostatic	17.1		2511.		6535			634	41284.
Toggle	26.0		568.	2786.	7193			474	18605.
Stepping								21368	
Solenoid	400.								
Motor Driven	109.3	715.	90909		62151			25641.	100000.
Inertial	138.2								
<u>ROTATING DEVICES</u>									
AC Generator	795.5		<500000	523256	1105253		23460	39918.	466667.
Slip Ring Assy.	<120.1	<2451.	<2288.	49879					214286.
Torquer Motor	308.8		<4566.						
Resolvers &									
Synchros	140.9								
AC Motor	431.6								
DC Motor	34.4								
Blowers & Fans	36.1								

## ELECTROMECHANICAL DEVICES

PART TYPE	STORAGE FAILURE RATE IN FITS	OPERATIONAL FAILURE RATE IN FITS						HELI-COPTER
		SATELLITE	GROUND MOBILE	AIR-BORNE	MISSILE	SHIP-BOARD	SUB-MARINE	
TRANSDUCERS, PRESSURE	1905	75269	79055	94520				154622
ANTENNA ASSY.	11.7	<1835	9000000	90231				116894
ROTARY INVERTER	<46.3							

**HYDRAULIC & PNEUMATIC DEVICES**

PART TYPE	STORAGE FAILURE RATE IN FITS	OPERATIONAL FAILURE RATE IN FITS								HELI-COPTER
		SATELLITE	GROUND	MOBILE	AIR-BORNE	MISSILE	SHIP-BOARD	SUB-MARINE		
<u>ACCUMULATORS</u>		<18500 1500	250000 55800	29800 15006	17700 118000	- 1500	-	-	-	500000 80300
General	32.5									712794
Hydraulic	32.6									712794
<u>ACTUATORS</u>										108000
General	167.	-	-	-	-	50400	-	-	-	107000
Linear, Elec.	167.	-	-	-	-	66900	-	-	-	-
Hydrau., Gen.	199.	-	15200	53300	137000	-	-	-	-	-
Hydrau., Servo	199.	-	126000	-	130000	-	-	-	-	-
Mechanical										-
Driven	167.	-	-	-	58000	-	-	-	-	-
Pneu., Gen/Lin	87.9	-	12104	-	204000	-	-	-	-	-
Pneu., Piston	87.9	-	1510	-	-	172000	-	-	-	107330
Rotary, Gen.	167.	-	-	-	-	<8550	-	-	-	-
Rotary, Elec.	167.	-	-	-	-	-	-	-	-	484.
<u>BATTERIES</u>										-
Silver Zinc	<42.4									
Thermal	94.3									
Rechargeable										
Rechargeable/										
Solar	-	132.	1498.	27027	348852					
<u>BEARINGS</u>										
General	14.5	-	2060	21900	8200	-	-	-	-	16200
Ball	14.5	<751	946	94	3420	-	<45500	4730	-	13400
Needle	14.5	-	-	<2970	-	-	-	-	-	-
Roller	14.5	-	280	-	284	-	1210	-	-	24000
Spherical	14.5	-	-	206	6380	-	-	-	-	26600
Sleeve	14.5	-	-	-	-	-	-	-	-	40000
<u>COMPRESSORS</u>										
General	<4080.	-	12700	-	297000	-	-	-	-	500000
<u>CYLINDERS</u>										
General	75.0	-	33200	-	212000	-	-	-	-	973000

## HYDRAULIC &amp; PNEUMATIC DEVICES

		OPERATIONAL FAILURE RATE IN FITS								
PART TYPE	STORAGE FAILURE RATE IN FITS	SATELLITE	GROUND	MOBILE	AIR-BORNE	MISSILE	SHIP-BOARD	SUB-MARINE	MARINE	HELI-COPTER
<u>FILTERS</u>										
<u>NON-ELECTRIC</u>										
General	<1.42	<225	<11800	73700	3.34	-	-	-	-	1990
Gaseous	<1.42	-	1200	1670	26600	-	-	-	-	26000
Liquid	<1.42	-	2990	11400	26200	-	-	-	-	49500
<u>FITTINGS</u>										
General	<1510.									29655
Quick Disconn.	Quick Disconn.									
Liquid, Gd.	Liquid, Gd.	<1510.								
Quick Disconn.	Quick Disconn.									
Liquid, Sub.	Liquid, Sub.									
499.	499.									
Hydraulic	Hydraulic									
<2776.	<2776.									
Swivel, Hydrav.	Swivel, Hydrav.									
<u>GASKETS</u>										
General	11.	-								
O-Rings	78.	-								
Packing	1.5	-								
<u>GASKETS &amp; SEALS</u>										
General	9.98	-								
Magnetic	23.	-								
Pressure	9.98	-								

		OPERATIONAL FAILURE RATE IN FITS							
PART TYPE	STORAGE FAILURE RATE IN FITS	SATELLITE	GROUND	GROUND MOBILE	AIR-BORNE	MISSILE	SHIP-BOARD	SUB-MARINE	HELI-COPTER
<u>HOSES</u>									
Flexible Metal	1746.				240	115830			40046
<u>PUMPS</u>									
General	406.	-	4220	-	109000	-	43600	25700	328000
<u>PUMPS, FIXED DISPLACEMENT</u>									
General	380.	-	-	-	-	-	-	-	-
Gear	439.	-	-	-	-	-	-	-	-
Piston	350.	-	-	-	-	-	-	-	-
Vane	300.	-	-	-	-	-	-	-	-
<u>PUMPS, VARIABLE DISPLACEMENT</u>									
General	475.	-	-	-	-	-	-	-	-
Piston	544.	-	-	-	-	-	-	-	-
Vane	406.	-	-	-	-	-	-	-	-
<u>PUMPS</u>									
Centrifugal	200.	-	12100	-	-	-	298000	-	-
Fuel Boost	<124.	-	24400	23100	45100	-	-	-	159000
Fuel Jettison	<124.	-	176000	-	69100	-	-	-	200000
Fuel Transfer	<124.	-	-	-	13000	-	-	-	-
Hyd. Driven	<124.	-	-	-	-	188000	-	-	366000
Hydrau., Gen.	95.3	-	1680	67000	458000	-	-	-	-
Manual	95.3	-	-	-	-	2300	-	-	-
Variable Delivery	95.3	-	-	-	-	17600	-	-	166000

HYDRAULIC AND PNEUMATIC DEVICES

		OPERATIONAL FAILURE RATE IN FITS							
		SATELLITE	GROUND	MOBILE	AIR-BORNE	MISSILE	SHIP-BOARD	SUB-MARINE	HELICOPTER
PART TYPE	STORAGE FAILURE RATE IN FITS								
<u>PUMPS</u> (cont'd)									
Impeller Oil	406.406.	-	<1900	-	-	59500	-	-	-
<u>REGULATORS</u>									
General	173.	-	-	-	-	108000	-	-	-
Bellmouth Controller, Jet Engine	173.	-	-	-	-	95600	-	-	-
Fluid, Tension	173.	-	-	-	-	5220	-	-	-
Fuel Pressure	1330.	2860	10700	2250	-	179000	-	-	136000
Temperature	<199.	3480	4340	17400	-	125000	-	-	-
<u>VALVES</u>									
General	12.4	-	14900	1180	65300	136000	-	-	98800
General, Ball	12.4	-	<235	1440	-	-	-	-	-
General, Butterfly	12.4	-	166	-	<100	-	-	-	-
General, Check	12.4	-	3010	-	28000	-	-	-	10000
General, Control	12.4	-	-	-	107000	-	-	-	-
General, Globe	12.4	-	<202	-	-	30700	-	-	-
General, Relief	12.4	-	1510	8770	-	-	-	-	148000
General, Selector	12.4	-	-	<21700	95200	-	-	-	-
General, Sequence	194.0	-	-	-	-	-	-	-	-
General, Shut-off	12.4	-	-	14200	93000	-	-	-	30500
General, Solenoid	8.5	-	<2620	16900	101000	-	-	-	125000
Free.:	1380.	-	-	-	22600	-	-	-	-
<u>VALVES, FUEL</u>									
General	84.4	-	<9090	<1270	38100	-	-	-	-
Check	235.	-	-	<2600	2850	-	-	-	40000

HYDRAULIC AND PNEUMATIC DEVICES

PART TYPE	STORAGE FAILURE RATE IN FITS	OPERATIONAL FAILURE RATE IN FITS						SUB-MARINE	HELI-COPTER
		SATELLITE	GROUND	MOBILE	AIR-BORNE	MISSILE	SHIP-BOARD		
<b>VALVES, FUEL (cont'd)</b>									
Dump	84.4	-	-	-	-	1420	-	-	-
Float	84.4	-	-	-	-	67100	-	-	40000
Gate	84.4	-	-	-	-	37600	-	-	71400
Pressure Regulator	2390.	-	-	-	-	65000	-	-	55300
Selector	84.4	-	-	-	-	42900	-	-	-
Shutoff	84.4	-	-	-	-	16200	-	-	-
Solenoid	84.4	-	1280	-	-	57700	-	-	-
<b>VALVES, HYDRAULIC</b>									
General	2.82	-	2710	7360	34900	-	-	-	-
Ball	374.	-	-	-	-	-	-	-	-
Bleeder	<4.75	-	-	-	-	-	-	-	-
Check	22.9	-	-	-	-	12600	-	-	-
Control	<6.66	-	-	-	-	103000	-	-	-
Pressure Regulator	-	-	-	-	-	-	-	-	-
Luator	2.82	-	-	8420	28400	-	-	-	-
Relief	1.4	-	868	14700	-	-	-	-	42900
Restrictor	5.55	-	-	-	-	19400	-	-	-
Sequencer	2.82	-	-	-	-	19800	-	-	-
Servo	146.	-	<71400	-	-	158000	-	-	316000
Shuttle	146.	-	-	-	-	63300	-	-	-
Shut-off	<4.66	-	-	-	-	4640	-	-	300000
Solenoid	8.53	-	-	-	-	44500	-	-	-
Spool, 4-way	2.82	-	-	-	-	174000	-	-	-
<b>VALVE, OIL</b>									
General	12.4	-	4220	-	36800	-	-	-	-
<b>VALVES, PNEUMATIC</b>									
General	214.	-	6640	-	-	61400	-	-	-
Bleed	214.	-	<1840	-	-	218000	-	-	213000
Check	<242.	-	1200	-	-	7340	-	-	-
Control	17.5	-	-	-	-	80100	-	-	-
Pressure, Regulator	<1590.	<228	20400	20400	116000	-	-	-	-

## HYDRAULIC AND PNEUMATIC DEVICES

PART TYPE	STORAGE FAILURE RATE IN FITS	OPERATIONAL FAILURE RATE IN FITS						HELI-COPTER
		SATELLITE	GROUND	GROUND MOBILE	AIR-BORNE	MISSILE BOARD	SUB-MARINE	
VALVES, PNEUMATIC								
Relief	17.5	-	79	469C	8010	-	-	9760
Selector	17.5	-	-	-	289000	-	-	-
Shut-off	17.5	-	-	-	69900	-	-	-
Solenoid	17.5	-	-	-	1990	-	-	-
VALVES, MOTOR OPERATED								
General	113.	-	-	-	-	-	-	
Sequence	194.	-	-	-	-	-	-	
Freon	<1500.	-	34500	-	-	-	-	
Fuel	84.4	-	8230	-	-	-	-	

## ORDNANCE DEVICES

		OPERATIONAL FAILURE RATE IN FITS								
PART TYPE	STORAGE FAILURE RATE IN FITS	GROUND BENIGN	SPACE FLIGHT	GROUND FIXED	AIR-BORNE INHAB.	NAVAL SHEL.	GROUND MOBILE	NAVAL UNSHEL	AIR-BORNE UNINHAB.	MISSILE LAUNCH
ORDNANCE DEVICES										
	SEE APPENDIX B									

## OPTICAL &amp; ELECTRO-OPTICAL DEVICES

PART TYPE	STORAGE FAILURE RATE IN FITS	OPERATIONAL FAILURE RATE IN FITS						MISSILE LAUNCH
		GROUND BENIGN	SPACE FLIGHT	GROUND FIXED	AIR-BORNE INHAB.	NAVAL SHEL.	GROUND MOBILE	
<b>OPTICAL &amp; ELECTRO-OPTICAL DEVICES</b>								
Lasers	TBD							
Vidicon Electron Tube	143.8							
Video Signal Detector Assy	47.2							
Lens Assembly	<48.3							
Sun Shutter Assy	340.							
Vidicon Cable	48.6							
SEE APPENDIX D								

## SECTION 3

### FAILURE RATE STATISTICS AND RANGES

Statistics and ranges for each of the failure rates in Section 2.0 are contained in the following pages. Further detail is available in report LC-78-2, "Storage Reliability Analysis Summary Report," dated February 1978.

The failure rate data is presented in two formats, one for electrical and electronic and a second for non-electronic. These formats are described below.

#### 3.1 Part Category and Description

All devices are identified by the generic category and are further defined in the description. The major categories are listed in Table 3-1 with the corresponding page number which begins that category. Included are electronic, electrical, electromechanical, hydraulic, pneumatic, ordnance, optical and electro-optical devices. Note that for hybrid microelectronic devices, vacuum tubes, ordnance and laser devices, the user is referred to detailed models in the appendices. In the case of hybrids and laser devices, the diversity of types precludes a simple classification and failure rate prediction. In the case of vacuum tubes and ordnance devices, aging trends have been identified which do not fit the exponential distribution assumption.

#### 3.2 Non-Operating Data

The non-operating data for both data formats is identical. The following parameters are listed:

Failures

Part Hours ( $10^6$ ) - Million hours

Failure rate in Fits - Failures per billion hours

Best Estimate

90% Confidence - One-sided upper limit

Range

- Low
- High

TABLE 3-1.  
DEVICE LIST

<u>MONOLITHIC MICROELECTRONICS</u>	<u>PAGE NO.</u>		<u>PAGE NO.</u>
<u>Bipolar Digital (TTL &amp; DTL)</u>		<u>Diodes (cont'd)</u>	
1-20 Gates	3-10	Silicon Microwave Detector	3-36
21-50 Gates	3-11	Germanium Microwave Detector	3-37
51-100 Gates	3-12	Silicon Microwave Mixer	3-38
<u>Bipolar Linear</u>		Germanium Microwave Mixer	3-39
<32 Trans.	3-13	Varactors, Step Recovery & Tunnel	3-40
33-100 Trans.	3-14	Silicon Controlled Rectifier	3-41
<u>Bipolar Memories</u>		<u>Vacuum Tubes</u>	
<1000 bits	3-15	Receiver Tubes Tetrode, Triode, Pentode	3-42
1001-4000 bits	3-16	Power Rectifier	3-43
4001-8000 bits	3-17	Klystron Low Power High Power	3-44 3-45
<u>MOS Devices</u>		Magnetron Medium Power High Power	3-46 3-47
1-20 Gates	3-18	TWT	
21-50 Gates	3-19	Peak Power <100 watts	3-48
51-100 Gates	3-20	Peak Power >100 watts <10,000 watts	3-49
<u>MOS Memories</u>		Transmitting Triode	3-50
<1000 bits	3-21	Tetrode & Pentode	3-51
1001-4000 bits	3-22		
4001-8000 bits	3-23		
<u>HYBRID MICROELECTRONICS</u>	3-24	<u>RESISTORS</u>	
<u>TRANSISTORS</u>		Fixed Composition (Insulated)	
Silicon NPN	3-25	MIL-R-39008	
Silicon PNP	3-26	Style RCR	3-52
Germanium PNP	3-27	MIL-R-11	
Germanium NPN	3-28	Style RC	3-53
Field Effect	3-29		
Unijunction	3-30		
Microwave	3-31		
<u>DIODES</u>			
Silicon General Purpose	3-32		
Germanium General Purpose	3-33		
Zener & Avalanche	3-34		
Thyristors	3-35		
	3-2		

TABLE 3-1. (cont'd)

DEVICE LIST

<u>RESISTORS (cont'd)</u>	<u>PAGE NO.</u>	<u>PAGE NO.</u>
<u>Fixed Film (Insulated)</u>		<u>Variable Wirewound Leadscrew Actuated</u>
MIL-R-39017 Style RLR	3-54	MIL-R-39015 Style RTR
MIL-R-22684 Style RL	3-55	MIL-R-27208 Style RT
<u>Fixed Film</u>		<u>Wirewound Potentiometers</u>
MIL-R-55182 Style RNR & RNC	3-56	Precision MIL-R-12934 Style RR
MIL-R-10509 Style RN	3-56	Semiprecision MIL-R-19 Style RA
<u>Power Film</u>		MIL-R-39002 Style RK
MIL-R-11804 Style RD/P	3-57	<u>Power</u> MIL-R-22 Style RP
<u>Fixed Wirewound Accurate</u>		<u>Variable (Non- Wirewound Trimmer)</u>
MIL-R-39005 Style RBR	3-58	MIL-R-39035 Style RJR
MIL-R-93 Style RB	3-59	MIL-R-22097 Style RJ
<u>Fixed Wirewound Power Type</u>		Composition (Low Precision) <u>Potentiometers</u>
MIL-R-39007 Style RWR	3-60	MIL-R-94 Style RV
MIL-R-26 Style RW	3-61	<u>Tin Oxide</u>
<u>Fixed Wirewound Power Type Chassis Mounted</u>		<u>Network</u>
MIL-R-39009 Style RER	3-62	<u>CAPACITORS</u>
MIL-R-18546 Style RE	3-63	Paper & Plastic Film
<u>THERMISTOR</u>		MIL-C-39022 Style CHR
MIL-T-23648 Style RTH	3-64	MIL-C-14157 Style CPV
		MIL-C-19978 Style CQR
		MIL-C-19978 Style CQ

TABLE 3-1. (cont'd)

DEVICE LIST

<u>CAPACITORS</u> (cont'd)	<u>PAGE NO.</u>	<u>CAPACITORS</u> (cont'd)	<u>PAGE NO.</u>
<u>Mica</u>		<u>Variable, Piston Type</u>	
MIL-C-39001 Style CMR	3-77	MIL-C-14409 Style PC	3-89
MIL-C-5 Style CM	3-78	<u>Titanium</u>	3-90
MIL-C-10950 Style CB	3-79	<u>Tubular Temp.</u>	3-91
<u>Glass</u>		<u>Differential, Dual Mode</u>	3-92
MIL-C-23269 Style CYR	3-80	<u>Metalized Polycarbonate</u>	3-93
<u>Ceramic</u>		<u>Variable, Air</u>	3-94
MIL-C-39014 Style CKR	3-81	<u>Network</u>	3-95
MIL-C-20 Style CCR	3-81	<u>INDUCTIVE DEVICES</u>	
MIL-C-11015 Style CK	3-82	<u>Transformers &amp; Inductors</u>	
MIL-C-20 Style CC	3-82	MIL-T-27	3-96
<u>Tantalum Electrolytic (Solid)</u>		MIL-T-39013	3-96
MIL-C-39003 Style CSR	3-83	<u>Coils, Radio Frequency</u>	
<u>Tantalum Electrolytic (Non-Solid)</u>		MIL-C-15305	3-97
MIL-C-39006 Style CLR	3-84	<u>Transformers Pulse, Low Power</u>	
MIL-C-3965 Style CL	3-85	MIL-T-21038	3-98
<u>Aluminum Oxide</u>		MIL-T-39026	3-98
MIL-C-39018 Style CU	3-86	<u>Filters &amp; Chokes</u>	3-99
<u>Aluminum Dry Electrolytic</u>		<u>Reactors</u>	3-100
MIL-C-62 Style CE	3-87	<u>MISC. E &amp; E</u>	
<u>Variable, Ceramic</u>		<u>Crystals</u>	3-101
MIL-C-81 Style CV	3-88	<u>Printed Wiring Board</u>	3-102
		<u>Connections &amp; Connectors</u>	
		Pin Connector	3-103
		Solder Connector	3-104
		Weld Connection	3-105
		<u>Instruments</u>	3-106
		<u>Fuses</u>	3-107
		<u>Heaters</u>	3-108

TABLE 3-1. (cont'd)

DEVICE LIST

<u>MISC. E &amp; E (cont'd)</u>	<u>PAGE NO.</u>	<u>Rotating Devices</u>	<u>PAGE NO.</u>
<u>Magnetic Core</u>	3-109	AC Generator	3-133
<u>Solar Cells</u>	3-110	Slip Ring Assy.	3-134
<u>Sensor, Temp.</u>	3-111	Torquer Motor	3-135
<u>Lamps</u>	3-112	Resolvers & Synchros	3-136
<u>ELECTROMECHANICAL</u>		AC Motor	3-137
<u>Accelerometer</u>		DC Motor	3-138
General	3-113	Blowers & Fans	3-139
<u>Gyroscope</u>		<u>Misc. Electromechanical Devices</u>	
Rate	3-114	Transducer, Pressure	3-140
<u>Relay</u>		Antenna Assy.	3-141
General	3-115	Rotary Inverter	3-142
Armature	3-116	<u>HYDRAULIC &amp; PNEUMATIC</u>	
Crystal Can, Latching	3-117	<u>Accumulators</u>	
Latching, General	3-118	General	3-143
Reed	3-119	Hydraulic	3-144
Thermal	3-120	<u>Actuators</u>	
Time Delay	3-121	General	3-145
<u>Switch</u>		Linear, Elect.	3-146
General	3-122	Hydrau., Gen.	3-147
Pressure	3-123	Hydraul, Servo	3-148
Pushbutton	3-124	Mechanical Driven	3-149
Rotary	3-125	Pneu., General & Linear	3-150
Sensitive	3-126	Pneu., Piston	3-151
Thermostatic	3-127	Rotary, Gen.	3-152
Toggle	3-128	Rotary, Elec.	3-153
Stepping	3-129	<u>Batteries</u>	
Solenoid	3-130	Silver Zinc	3-154
Motor Driven	3-131	Thermal	3-155
Inertial	3-132	Rechargeable	3-156
		Rechargeable, Solar	3-157

TABLE 3-1. (cont'd)

DEVICE LIST

<u>HYDRAULIC &amp; PNEUMATIC (cont'd)</u>	<u>PAGE NO.</u>	<u>Pumps, Fixed Displacement</u>	<u>PAGE NO.</u>
<u>Bearings</u>		General	3-182
General	3-158	Gear	3-183
Ball	3-159	Piston	3-184
Needle	3-160	Vane	3-185
<u>Roller</u>	3-161	<u>Pumps, Variable Displacement</u>	
<u>Spherical</u>	3-162	General	3-186
<u>Sleeve</u>	3-163	Piston	3-187
<u>Compressors</u>	3-164	Vane	3-188
General		<u>Pumps</u>	
<u>Cylinders</u>	3-165	Centrifugal	3-189
General		Fuel	3-190
<u>Filters Non-Electric</u>		Fuel Boost	3-191
General	3-166	Fuel Jettison	3-192
Gaseous	3-167	Fuel Transfer	
Liquid	3-168	Hyd. Driven	3-193
<u>Fittings</u>		Hydraul, Gen	3-194
General	3-169	Manual	3-195
Quick Disc.	3-170	Variable Delivery	3-196
Quick Disc.	3-171	Impeller	3-197
Hydraulic	3-172	Oil	3-198
Swivel	3-173	<u>Regulators</u>	/
<u>Gaskets &amp; Seals</u>		General	3-199
General	3-174	Bellmouth Controller,	
O-Rings	3-175	Jet Engine	3-200
Packing	3-176	Fluid Tension	3-201
Seals, Gen.	3-177	Fuel	3-202
Seals, Magn.	3-178	Pressure	3-203
Seals, Pressure	3-179	Temperature	3-204
<u>Hoses</u>		<u>Valves</u>	
Flexible Metal	3-180	General	3-205
<u>Pumps</u>		General, Ball	3-206
General	3-181	General, Butterfly	3-207

TABLE 3-1. (cont'd)

DEVICE LIST

<u>Valves (cont'd)</u>	<u>PAGE NO.</u>	<u>Valve, Oil</u>	<u>PAGE NO.</u>
General, Check	3-208	General	3-240
General, Control	3-209	<u>Valves, Pneumatic</u>	
General, Globe	3-210	General	3-241
General, Relief	3-211	Bleed	3-242
General, Selector	3-212	Check	3-243
General, Sequence	3-213	Control	3-244
General, Shutoff	3-214	Pressure, Regulator	3-245
General, Solenoid	3-215	Relief	3-246
Freon	3-216	Selector	3-247
<u>Valves, Fuel</u>		Shutoff	3-248
General	3-217	Solenoid	3-249
Check	3-218	<u>Valves, Motor Operated</u>	
Dump	3-219	General	3-250
Float	3-220	Sequence	3-251
Gate	3-221	Freon	3-252
Pressure Regulator	3-222	Fuel	3-253
Selector	3-223	<u>ORDNANCE</u>	3-254
Shutoff	3-224	Optical & Electro-optical Devices	
Solenoid	3-225	Lasers	3-255
<u>Valves, Hydraulic</u>		Vidicon	3-256
General	3-226	Video Detec.	3-257
Ball	3-227	Lens Assy.	3-258
Bleeder	3-228	Sun Shutter	3-259
Check	3-229	Vidicon Cable	3-260
Control	3-230		
Pressure Regulator	3-231		
Relief	3-232		
Restrictor	3-233		
Sequencer	3-234		
Servo	3-235		
Shuttle	3-236		
Shutoff	3-237		
Solenoid	3-238		
Spool, 4 Way	3-239		

The device failures listed represent part defects, aging, corrosion, etc. Secondary failures (for example, mishandling, faults caused by test equipment failure, design defects, etc.) are not included.

The part hours represent total non-operating hours experienced by all parts in the sample.

Four measures of failure rate are given. The first is the best estimate and is the number of failures divided by the total part hours.

The 90% confidence failure rate represents a 90% confidence that the failure rate is equal to or less than this value. This statistic is based on the chi-square distribution.

The low and high failure rate range, where available, represents the best and the worst reliability experience of the numerous sources from which data was collected.

### 3.3 Electrical and Electronic Operating Data

The majority of the electrical and electronic operating data was extracted from MIL-HDBK-217B, "Reliability Prediction of Electronic Equipment," dated 20 September 1974.

For this data, part failure and hours are not available and therefore do not appear on the data sheets. Statistics given include failure rate in fits with the best estimate and low and high ranges.

The best estimate was extracted from the parts count predictions in Section 3 of MIL-HDBK-217B.

The low and high failure rate ranges were also extracted from MIL-HDBK-217B. For each device type and environment, the detailed failure rate models were exercised with the least severe stress and complexity and the most severe stress and complexity. The resulting failure rates were then recorded as the low and high range respectively.

### 3.4 Non-Electronic Operating Data

The majority of the non-electronic operating data was extracted from RADC-TR-74-268, "Revision of RADC Nonelectronic

*Reliability Notebook," dated October 1974.*

For this data, the format is identical to the non-operating data. However, no information on low or high failure rate ranges is available.

### 3.5 Environmental Factors

Operating data is presented for various environments as described in Section 1. Environmental factors are listed in this section for each environment for the convenience of the user. The non-operating environment is used as the base environment with a factor equal to 1.0. The other environmental factors are a ratio to the non-operating environment. These were calculated using the best estimate failure rate for all environments. Each environment failure rate was divided by the non-operating failure rate to obtain the factor.

### 3.6 Quality Factors

For a large portion of the electrical and electronic devices, data is broken out by the quality level of the device. For microelectronic devices, Class A, B and C quality levels are listed. The levels are defined in MIL-STD-883.

For discrete semiconductor devices, JANTXV, JANTX, and JAN quality levels are listed. These levels are defined in MIL-S-19500.

For other electrical and electronic devices, various quality classifications are used and are defined in the noted military specification.

Quality factors are given separately for non-operating and operating environments. They are obtained by defining one level as a base with a factor equal to one. Then the best estimate failure rate for that quality level is divided into the other quality level failure rates to determine the failure rate ratio to the base quality level.

PART CATEGORY: MONOLITHIC MICROELECTRONIC DEVICES

DESCRIPTION: BIPOAR DIGITAL (1-20 GATES)

ENVIRONMENT	FAILURES	PART HOURS ( $10^6$ )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
<u>NON-OPERATING</u>						
GROUND, FIXED						
CLASS C*	8	2103.	3.73	6.18	-	4.1
CLASS B*	22	6672.	3.30	4.38	1.7	48.5
CLASS A*	5	5861.	0.85	1.59	-	1.87

ENVIRONMENT	FAILURE RATE IN FITS						
	CLASS C			CLASS B			
	RANGE	LOW	BEST EST	HIGH	LOW	BEST EST	HIGH
<u>OPERATING</u>							
GROUND, BENIGN	12.9		56.	724.	1.61	7.	9.
SPACE FLIGHT	12.9		56.	724.	1.61	7.	91.
GROUND, FIXED	64.5		232.	3620.	8.06	29.	453.
AIRBORNE, INHAB	258.		728.	14500.	32.2	91.	1810.
NAVAL, SHELTERED	258.		744.	14500.	32.2	93.	1810.
GROUND, MOBILE	258.		728.	14500.	32.2	91.	1810.
NAVAL, UNSHEL	322.		960.	18100.	40.3	120.	2270.
AIRBORNE, UNINHAB	387.		1120.	21700.	48.4	140.	2720.
MISSILE, LAUNCH	645.		1680.	36200.	80.6	210.	4530.

ENVIRONMENTAL FACTORS											
NON-OPERATING				OPERATING							
G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>		
CLASS C	1.0	15.	15.	62.	195.	199.	195.	257.	300.	450.	
CLASS B	1.0	2.1	2.1	8.8	28.	28.	28.	36.	42.	64.	

QUALITY FACTORS											
NON-OPERATING				OPERATING							
CLASS C	CLASS B	CLASS A		CLASS C	CLASS B	CLASS A					
4.4	3.9	1		8	1	.5					

\*Mono metal - metallization/interconnection system.

PART CATEGORY: MONOLITHIC MICROELECTRONIC DEVICES

DESCRIPTION: BIPOLAR DIGITAL (21-50 GATES)

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
NON-OPERATING						
GROUND, FIXED						
CLASS C	*	*	3.73	6.18	-	4.1
CLASS B	*	*	3.30	4.38	1.7	48.5
CLASS A	*	*	0.85	1.59	-	1.87

ENVIRONMENT	FAILURE RATE IN FITS					
	CLASS C			CLASS B		
	RANGE		RANGE			
ENVIRONMENT	LOW	BEST EST	HIGH	LOW	BEST EST	HIGH
OPERATING						
GROUND, BENIGN	38.4	160.	1320	4.8	20.	165.
SPACE FLIGHT	38.4	160.	1320	4.8	20.	165.
GROUND, FIXED	192.	496.	6590	24.	62.	824.
AIRBORNE, INHAB	768.	1280.	26400	96.	160.	3300.
NAVAL, SHELTERED	768.	1360.	26400	96.	170.	3300.
GROUND, MOBILE	768.	1280.	26400	96.	160.	3300.
NAVAL, UNSHEL	960.	1840.	33000	120.	230.	4120.
AIRBORNE, UNINHAB	1150.	2000.	40000	120.	250.	4940.
MISSILE, LAUNCH	1920.	2720.	65900	240.	340.	8240.

ENVIRONMENTAL FACTORS											
NON-OPERATING				OPERATING							
G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>		
CLASS C	1.0	43.	43.	133.	343.	365.	343.	493.	536.	729.	
CLASS B	1.0	6.1	6.1	19.	48.	52.	48.	70.	76.	103.	

QUALITY FACTORS											
NON-OPERATING				OPERATING							
CLASS C	CLASS B	CLASS A		CLASS C	CLASS B	CLASS A					
4.4	3.9	1.		8	1	.5					

\*See Bipolar, Digital (1-20 gates).

PART CATEGORY: MONOLITHIC MICROELECTRONIC DEVICES

DESCRIPTION: BIPOLAR DIGITAL (51-100 GATES)

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
NON-OPERATING GROUND, FIXED					-	4.1
CLASS C	*	*	3.73	6.18	-	4.1
CLASS B	*	*	3.30	4.38	1.7	48.5
CLASS A	*	*	0.85	1.59	-	1.87

ENVIRONMENT	FAILURE RATE IN FITS					
	CLASS C			CLASS B		
	LOW	BEST EST	HIGH	LOW	BEST EST	HIGH
OPERATING						
GROUND, BENIGN	57.	256.	2120	7.1	32.	264.
SPACE FLIGHT	57.	256.	2120	7.1	32.	264.
GROUND, FIXED	285.	752.	10600	35.6	94.	1320.
AIRBORNE, INHAB	1140.	1840.	42400	142.	230.	5280.
NAVAL, SHELTERED	1140.	1920.	42400	142.	240.	5280.
GROUND, MOBILE	1140.	1840.	42400	142.	230.	5280.
NAVAL, UNSHEL	1425.	2720.	53000	178.	340.	6600.
AIRBORNE, UNINHAB	1710.	2880.	63600	214.	360.	7920.
MISSILE, LAUNCH	2850.	3760.	106000	356.	470.	

ENVIRONMENTAL FACTORS										
NON-OPERATING			OPERATING							
G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>	
CLASS C 1.0	69.	69.	202.	493.	515.	493.	729.	772.	1008.	
CLASS B 1.0	9.7	9.7	28.	70.	73.	70.	103.	109.	142.	

QUALITY FACTORS										
NON-OPERATING			OPERATING							
CLASS C	CLASS B	CLASS A	CLASS C	CLASS B	CLASS A	8	1	.5		
4.4	3.9	1								

\*See Bipolar Digital (1-20 gates).

PART CATEGORY: MONOLITHIC MICROELECTRONIC DEVICES

DESCRIPTION: BIPOLEAR LINEAR (< 32 TRANSISTORS)

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
NON-OPERATING GROUND, FIXED						
CLASS C	*	*	3.73	6.18	-	4.1
CLASS B	*	*	3.30	4.38	1.7	48.5
CLASS A	*	*	0.85	1.59	-	1.87

ENVIRONMENT	FAILURE RATE IN FITS						
	CLASS C			CLASS B			
	RANGE	LOW	BEST EST.	HIGH	LOW	BEST EST.	HIGH
OPERATING							
GROUND, BENIGN	18.4	96.	22400	2.3	12.	2800	
SPACE FLIGHT	18.4	96.	22400	2.3	12.	2800	
GROUND, FIXED	92.	416.	112000	11.5	52.	14000	
AIRBORNE, INHAB	368.	1200.	448000	46.0	150.	56000	
NAVAL, SHELTERED	368.	1280.	448000	46.0	160.	56000	
GROUND, MOBILE	368.	1200.	448000	46.0	150.	56000	
NAVAL, UNSHEL	460.	2160.	560000	57.5	270.	70000	
AIRBORNE, UNINHAB	552.	2160.	572000	69.0	270.	84000	
MISSILE, LAUNCH	920.	2640.	1x10 <sup>6</sup>	115.0	330.	1x10 <sup>5</sup>	

ENVIRONMENTAL FACTORS											
NON-OPERATING				OPERATING							
G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>		
CLASS C 1.0	26.	26.	112.	322.	343.	322.	570.	579.	708.		
CLASS B 1.0	3.6	3.6	16.	45.	48.	45.	82.	82.	100.		

QUALITY FACTORS											
NON-OPERATING				OPERATING							
CLASS C	CLASS B	CLASS A		CLASS C	CLASS B	CLASS A					
4.4	3.9	1		8	1	.5					

\*See Bipolar, Digital (1-20 gates).

PART CATEGORY: MONOLITHIC MICROELECTRONIC DEVICES

DESCRIPTION: BIPOLAR LINEAR (33-100 TRANSISTORS)

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
					LOW	HIGH
NON-OPERATING GROUND, FIXED						
CLASS C	*	*	3.73	6.18	-	4.1
CLASS B	*	*	3.30	4.38	1.7	48.5
CLASS A	*	*	0.85	1.59	-	1.87

ENVIRONMENT	FAILURE RATE IN FITS						
	CLASS C			CLASS B			
	RANGE		RANGE		LOW	BEST EST	HIGH
OPERATING							
GROUND, BENIGN	56.8	208.	56000	7.1	26.	7000	
SPACE FLIGHT	56.8	208.	56000	7.1	26.	7000	
GROUND, FIXED	284.	960.	280000	35.5	120.	35000	
AIRBORNE, INHAB	1136.	2560.	1x10 <sup>6</sup>	142.	320.	1x10 <sup>5</sup>	
NAVAL, SHELTERED	1136.	2800.	1x10 <sup>6</sup>	142.	350.	1x10 <sup>5</sup>	
GROUND, MOBILE	1136.	2560.	1x10 <sup>6</sup>	142.	320.	1x10 <sup>5</sup>	
NAVAL, UNSHEL	1420.	4800.	1x10 <sup>6</sup>	177.	600.	2x10 <sup>5</sup>	
AIRBORNE, UNINHAB	1700.	4880.	2x10 <sup>6</sup>	213.	610.	2x10 <sup>5</sup>	
MISSILE, LAUNCH	2840.	5440.	3x10 <sup>6</sup>	355.	680.	4x10 <sup>5</sup>	

ENVIRONMENTAL FACTORS											
NON-OPERATING				OPERATING							
	G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>	
CLASS C	1.0	56.	56.	257.	686.	751.	686.	1287	1308	1450	
CLASS B	1.0	7.9	7.9	36.	97.	106.	97.	182.	185.	206.	

QUALITY FACTORS											
NON-OPERATING				OPERATING							
CLASS C	CLASS B	CLASS A		CLASS C	CLASS B	CLASS A					
4.4	3.9	1		8		1					.8

\*See Bipolar, Digital (1-20 gates).

PART CATEGORY: MONOLITHIC MICROELECTRONIC DEVICES

DESCRIPTION: BIPOLEAR MEMORIES (< 1000 BITS)

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS		
			BEST ESTIMATE	90% CONFIDENCE	RANGE
LOW	HIGH				
NON-OPERATING					
GROUND, FIXED					
CLASS C					
CLASS B					

ENVIRONMENT	FAILURE RATE IN FITS					
	CLASS C			CLASS B		
	RANGE		RANGE			
LOW	BEST EST	HIGH	LOW	BEST EST	HIGH	
OPERATING						
GROUND, BENIGN	8.	960.	6600	1.	120.	824
SPACE FLIGHT	8.	960.	6600	1.	120.	824
GROUND, FIXED	40.	2400.	33000	5.	300.	4120
AIRBORNE, INHAB	160.	4880.	132000	20.	610.	16500
NAVAL, SHIELDED	160.	5360.	132000	20.	670.	16500
GROUND, MOBILE	160.	4880.	132000	20.	610.	16500
NAVAL, UNSHEL	200.	7840.	165000	25.	980.	20600
AIRBORNE, UNINHAB	240.	7920.	198000	30.	990.	24700
MISSILE, LAUNCH	400.	8800.	330000	50.	1100.	4x10 <sup>4</sup>

ENVIRONMENTAL FACTORS									
NON-OPERATING			OPERATING						
G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>
CLASS C									
CLASS B									

QUALITY FACTORS									
NON-OPERATING			OPERATING						
CLASS C	CLASS B	CLASS A	CLASS C	CLASS B	CLASS A	8	1	.5	

PART CATEGORY: MONOLITHIC MICROELECTRONIC DEVICES

DESCRIPTION: BIPOLAR MEMORIES (1001-4000 BITS)

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
					LOW	HIGH
NON-OPERATING GROUND, FIXED						
CLASS C						
CLASS B						

ENVIRONMENT	FAILURE RATE IN FITS					
	CLASS C			CLASS B		
	LOW	BEST EST.	HIGH	LOW	BEST EST.	HIGH
OPERATING						
GROUND, BENIGN	440.	2080.	16500	55.	260.	2060
SPACE FLIGHT	440.	2080.	16500	55.	260.	2060
GROUND, FIXED	2200.	5600.	82400	275.	700.	10300
AIRBORNE, INHAB	8800.	11200.	330000	1100.	1400.	41200
NAVAL, SHELTERED	8800.	12000.	330000	1100.	1500.	41200
GROUND, MOBILE	8800.	11200.	330000	1100.	1400.	41200
NAVAL, UNSHEL	11000.	18400.	412000	1375.	2300.	51500
AIRBORNE, UNINHAB	13200.	18400.	494000	1650.	2300.	61800
MISSILE, LAUNCH	22000.	20800.	824000	2750.	2600.	1x10 <sup>5</sup>

ENVIRONMENTAL FACTORS											
NON-OPERATING				OPERATING							
G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>T</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>		
CLASS C											
CLASS B											

QUALITY FACTORS											
NON-OPERATING				OPERATING							
CLASS C	CLASS B	CLASS A		CLASS C	CLASS B	CLASS A					
				8	1	.5					

PART CATEGORY: MONOLITHIC MICROELECTRONIC DEVICES

DESCRIPTION: BIPOAR MEMORIES (4001 - 8000 BITS)

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS		
			BEST ESTIMATE	90% CONFIDENCE	RANGE
			LOW	HIGH	
NON-OPERATING GROUND, FIXED					
CLASS C					
CLASS B					

ENVIRONMENT	FAILURE RATE IN FITS						
	CLASS C			CLASS B			
	RANGE		RANGE		LOW	BEST EST	HIGH
OPERATING							
GROUND, BENIGN	278	3520.	21400	34.8	440.	2680	
SPACE FLIGHT	278	3520.	21400	34.8	440.	2680	
GROUND, FIXED	1390	9600.	107000	174.	1200.	13400	
AIRBORNE, INHAB	5560	19200.	428000	696.	2400.	53600	
NAVAL, SHELTERED	5560	20800.	428000	696.	2600.	53600	
GROUND, MOBILE	5560	19200.	428000	696.	2400.	53600	
NAVAL, UNSHEL	6950	30400.	535000	870.	3800.	67000	
AIRBORNE, UNINHAB	8340	31200.	642000	1044.	3900.	80400	
MISSILE, LAUNCH	13900	36000.	1x10 <sup>6</sup>	1740.	4500.	1x10 <sup>5</sup>	

NON-OPERATING	ENVIRONMENTAL FACTORS									
	OPERATING									
	G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>
CLASS C										
CLASS B										

QUALITY FACTORS									
NON-OPERATING			OPERATING						
CLASS C	CLASS B	CLASS A	CLASS C	CLASS B	CLASS A	8	1	.5	

PART CATEGORY: MONOLITHIC MICROELECTRONIC DEVICES

DESCRIPTION: MOS (1-20 GATES)

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			RANGE
			BEST ESTIMATE	90% CONFIDENCE	LOW	
			HIGH			
NON-OPERATING						
GROUND, FIXED						
CLASS C						
CLASS B						

ENVIRONMENT	FAILURE RATE IN FITS					
	CLASS C			CLASS B		
	RANGE		RANGE			
OPERATING	LOW	BEST EST	HIGH	LOW	BEST EST	HIGH
GROUND, BENIGN	13.	80.	28800	1.6	10.	3600
SPACE FLIGHT	13.	80.	28800	1.6	10.	3600
GROUND, FIXED	65.	384.	144000	8.1	48.	18000
AIRBORNE, INHAB	260.	960.	576000	32.	120.	72000
NAVAL, SHELTERED	260.	1120.	576000	32.	140.	72000
GROUND, MOBILE	260.	960.	576000	32.	120.	72000
NAVAL, UNSHEL	325.	2000.	720000	40.	250.	90000
AIRBORNE, UNINHAB	390.	1920.	864000	49.	240.	1x10 <sup>5</sup>
MISSILE, LAUNCH	650.	1920.	1x10 <sup>6</sup>	81.	240.	2x10 <sup>5</sup>

ENVIRONMENTAL FACTORS									
NON-OPERATING			OPERATING						
G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>
CLASS C									
CLASS B									

QUALITY FACTORS									
NON-OPERATING			OPERATING						
CLASS C	CLASS B	CLASS A	CLASS C	CLASS B	CLASS A	8	1	.5	

PART CATEGORY: MONOLITHIC MICROELECTRONIC DEVICES

DESCRIPTION: MOS ( 21-50 GATES)

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS		
			BEST ESTIMATE	90% CONFIDENCE	RANGE
LOW	HIGH				
NON-OPERATING					
GROUND, FIXED					
CLASS C					
CLASS B					

ENVIRONMENT	FAILURE RATE IN FITS					
	CLASS C			CLASS B		
	RANGE		RANGE			
LOW	BEST EST	HIGH	LOW	BEST EST	HIGH	
<u>OPERATING</u>						
GROUND, BENIGN	38.	384.	52800	4.8	48.	6600
SPACE FLIGHT	38.	384.	52800	4.8	48.	6600
GROUND, FIXED	192.	1520.	264000	24.	190.	33000
AIRBORNE, INHAB	768.	2720.	1x10 <sup>6</sup>	96.	340.	1x10 <sup>5</sup>
NAVAL, SHELTERED	768.	3440.	1x10 <sup>6</sup>	96.	430.	1x10 <sup>5</sup>
GROUND, MOBILE	768.	2720.	1x10 <sup>6</sup>	96.	340.	1x10 <sup>5</sup>
NAVAL, UNSHEL	960.	7360.	1x10 <sup>6</sup>	120.	920.	2x10 <sup>5</sup>
AIRBORNE, UNINHAB	1150.	6320.	2x10 <sup>6</sup>	144.	790.	2x10 <sup>5</sup>
MISSILE, LAUNCH	1920.	4160.	3x10 <sup>6</sup>	240.	520.	3x10 <sup>5</sup>

ENVIRONMENTAL FACTORS											
NON-OPERATING				OPERATING							
G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>		
CLASS C											
CLASS B											

QUALITY FACTORS											
NON-OPERATING				OPERATING							
CLASS C	CLASS B	CLASS A		CLASS C	CLASS B	CLASS A					
				8	1	.5					

PART CATEGORY: MONOLITHIC MICROELECTRONIC DEVICES

DESCRIPTION: MOS ( 51-100 GATES)

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			RANGE
			BEST ESTIMATE	90% CONFIDENCE		
			LOW	HIGH		
NON-OPERATING						
GROUND, FIXED						
CLASS C						
CLASS B						

ENVIRONMENT	FAILURE RATE IN FITS					
	CLASS C			CLASS B		
	RANGE		RANGE			
OPERATING	LOW	BEST EST	HIGH	LOW	BEST EST	HIGH
GROUND, BENIGN	58.	608.	84800	7.2	76.	10600
SPACE FLIGHT	58.	608.	84800	7.2	76.	10600
GROUND, FIXED	288.	2480.	424000	36.	310.	53000
AIRBORNE, INHAB	1150.	4320.	2x10 <sup>6</sup>	144.	540.	2x10 <sup>5</sup>
NAVAL, SHELTERED	1150.	5440.	2x10 <sup>6</sup>	144.	680.	2x10 <sup>5</sup>
GROUND, MOBILE	1150.	4320.	2x10 <sup>6</sup>	144.	540.	2x10 <sup>5</sup>
NAVAL, UNSHEL	1440.	12000.	2x10 <sup>6</sup>	180.	1500.	3x10 <sup>5</sup>
AIRBORNE, UNINHAB	1730.	10400.	3x10 <sup>6</sup>	216.	1300.	3x10 <sup>5</sup>
MISSILE, LAUNCH	2880.	6240.	4x10 <sup>6</sup>	360.	780.	5x10 <sup>5</sup>

ENVIRONMENTAL FACTORS									
NON-OPERATING					OPERATING				
G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>
CLASS C									
CLASS B									

QUALITY FACTORS									
NON-OPERATING					OPERATING				
CLASS C	CLASS B	CLASS A	CLASS C	CLASS B	CLASS A	8	1	.5	

PART CATEGORY: MONOLITHIC MICROELECTRONIC DEVICES

DESCRIPTION: MOS MEMORIES ( $\leq$  1000 BITS)

ENVIRONMENT	FAILURES	PART HOURS ( $10^6$ )	FAILURE RATE IN FITS		
			BEST ESTIMATE	90% CONFIDENCE	RANGE
					LOW    HIGH
NON-OPERATING GROUND, FIXED					
CLASS C					
CLASS B					

ENVIRONMENT	FAILURE RATE IN FITS					
	CLASS C			CLASS E		
	RANGE		RANGE		LOW	BEST EST
OPERATING	LOW	BEST EST	HIGH	LOW		
GROUND, BENIGN	8.	2560.	270000	1.	320.	33800
SPACE FLIGHT	8.	2560.	270000	1.	320.	33800
GROUND, FIXED	40.	9600.	$1 \times 10^6$	5.	1200.	$2 \times 10^5$
AIRBORNE, INHAB	160.	15200.	$5 \times 10^6$	20.	1900.	$7 \times 10^5$
NAVAL, SHELTERED	160.	19200.	$5 \times 10^6$	20.	2400.	$7 \times 10^5$
GROUND, MOBILE	160.	15200.	$5 \times 10^6$	20.	1900.	$7 \times 10^5$
NAVAL, UNSHEL	200.	45600.	$7 \times 10^6$	25.	5700.	$8 \times 10^5$
AIRBORNE, UNINHAB	240.	37600.	$8 \times 10^6$	30.	4700.	$1 \times 10^6$
MISSILE, LAUNCH	400.	19200.	$1 \times 10^7$	50.	2400.	$2 \times 10^6$

NON-OPERATING	ENVIRONMENTAL FACTORS									
	OPERATING									
	<u>G<sub>F</sub></u>	<u>G<sub>B</sub></u>	<u>S<sub>F</sub></u>	<u>G<sub>F</sub></u>	<u>A<sub>I</sub></u>	<u>N<sub>S</sub></u>	<u>G<sub>M</sub></u>	<u>N<sub>U</sub></u>	<u>A<sub>U</sub></u>	<u>M<sub>L</sub></u>
CLASS C										
CLASS B										

QUALITY FACTORS									
NON-OPERATING			OPERATING						
<u>CLASS C</u>	<u>CLASS B</u>	<u>CLASS A</u>	<u>CLASS C</u>	<u>CLASS B</u>	<u>CLASS A</u>	<u>8</u>	<u>1</u>	<u>.5</u>	

PART CATEGORY: MONOLITHIC MICROELECTRONIC DEVICES

DESCRIPTION: MOS MEMORIES (1001 - 4000 BITS)

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			RANGE
			REST ESTIMATE	90% CONFIDENCE		
			LOW	HIGH		
NON-OPERATING						
GROUND, FIXED						
CLASS C						
CLASS B						

ENVIRONMENT	FAILURE RATE IN FITS					
	CLASS C			CLASS B		
	RANGE		RANGE			
LOW	BEST EST	HIGH	LOW	BEST EST	HIGH	
OPERATING						
GROUND, BENIGN	11.	5600.	676000	1.4	700.	84400
SPACE FLIGHT	11.	5600.	676000	1.4	700.	84400
GROUND, FIXED	57.	21600.	3x10 <sup>6</sup>	7.1	2700.	4x10 <sup>5</sup>
AIRBORNE, INHAB	228.	34400.	1x10 <sup>7</sup>	28.4	4300.	2x10 <sup>6</sup>
NAVAL, SHELTERED	228.	44800.	1x10 <sup>7</sup>	28.4	5600.	2x10 <sup>6</sup>
GROUND, MOBILE	228.	34400.	1x10 <sup>7</sup>	28.4	4300.	2x10 <sup>6</sup>
NAVAL, UNSHEL	285.	104000.	2x10 <sup>7</sup>	35.5	13000.	2x10 <sup>6</sup>
AIRBORNE, UNINHAB	342.	88000.	2x10 <sup>7</sup>	42.6	11000.	3x10 <sup>6</sup>
MISSILE, LAUNCH	570.	44000.	3x10 <sup>7</sup>	710.	5500.	4x10 <sup>6</sup>

ENVIRONMENTAL FACTORS										
NON-OPERATING			OPERATING							
G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>T</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>	
CLASS C										
CLASS B										

QUALITY FACTORS										
NON-OPERATING			OPERATING							
CLASS C	CLASS B	CLASS A	CLASS C	CLASS B	CLASS A					
			8	1	.5					

PART CATEGORY: MONOLITHIC MICROELECTRONIC DEVICES

DESCRIPTION: MOS MEMORIES (4001 - 8000 BITS)

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS		
			BEST ESTIMATE	90% CONFIDENCE	RANGE
			LOW	HIGH	
NON-OPERATING					
GROUND, FIXED					
CLASS C					
CLASS B					

ENVIRONMENT	FAILURE RATE IN FITS					
	CLASS C			CLASS B		
	RANGE		RANGE			
OPERATING	LOW	BEST EST	HIGH	LOW	BEST EST	HIGH
GROUND, BENIGN	278.	9600.	880000	35.	1200.	1x10 <sup>5</sup>
SPACE FLIGHT	278.	9600.	880000	35.	1200.	1x10 <sup>5</sup>
GROUND, FIXED	1390.	36000.	4x10 <sup>6</sup>	174.	4500.	6x10 <sup>5</sup>
AIRBORNE, INHAB	5560.	57600.	2x10 <sup>7</sup>	696.	7200.	2x10 <sup>6</sup>
NAVAL, SHELTERED	5560.	75200.	2x10 <sup>7</sup>	696.	9400.	2x10 <sup>6</sup>
GROUND, MOBILE	5560.	57600.	2x10 <sup>7</sup>	696.	7200.	2x10 <sup>6</sup>
NAVAL, UNSHEL	6950.	176000.	2x10 <sup>7</sup>	870.	22000.	3x10 <sup>6</sup>
AIRBORNE, UNINHAB	8340.	144000.	3x10 <sup>7</sup>	1040.	18000.	3x10 <sup>6</sup>
MISSILE, LAUNCH	13900.	74400.	4x..	1740.	9300.	6x10 <sup>6</sup>

NON-OPERATING	ENVIRONMENTAL FACTORS									
	OPERATING									
	G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>
CLASS C										
CLASS B										

QUALITY FACTORS					
NON-OPERATING			OPERATING		
CLASS C	CLASS B	CLASS A	CLASS C	CLASS B	CLASS A
			8	1	.5

PART CATEGORY: HYBRID MICROELECTRONICS

DESCRIPTION: SEE APPENDIX A

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS		
			BEST ESTIMATE	90% CONFIDENCE	RANGE
LOW	HIGH				
NON-OPERATING					
GROUND, FIXED					
CLASS C					
CLASS B					

ENVIRONMENT	FAILURE RATE IN FITS					
	CLASS C			CLASS B		
	RANGE		RANGE		LOW	BEST EST
LOW	BEST EST	HIGH	LOW	BEST EST	HIGH	
OPERATING						
GROUND, BENIGN						
SPACE FLIGHT						
GROUND, FIXED						
AIRBORNE, INHAB						
NAVAL, SHELTERED						
GROUND, MOBILE						
NAVAL, UNSHEL						
AIRBORNE, UNINHAB						
MISSILE, LAUNCH						

ENVIRONMENTAL FACTORS											
NON-OPERATING				OPERATING							
G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>T</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>		
CLASS C											
CLASS B											

QUALITY FACTORS											
NON-OPERATING				OPERATING							
CLASS C	CLASS B	CLASS A		CLASS C	CLASS B	CLASS A					

PART CATEGORY: TRANSISTOR

DESCRIPTION: SILICON NPN

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
					LOW	HIGH
NON-OPERATING GROUND, FIXED						
JAN	20	2268	8.82	11.9	-	10.5
JANTX	30	19900	1.51	1.93	.75	62.9

ENVIRONMENT	FAILURE RATE IN FITS						
	JAN			JANTX			
	RANGE	LOW	BEST EST	HIGH	LOW	BEST EST	HIGH
OPERATING							
GROUND, BENIGN	4.		28.	150.	.8	5.6	30.
SPACE FLIGHT	4.		28.	150.	.8	5.6	30.
GROUND, FIXED	24.		180.	750.	4.7	36.	150.
AIRBORNE, INHAB	126.		980.	4350.	25.2	196.	870.
NAVAL, SHELTERED	134.		1100.	4950.	26.7	220.	990.
GROUND, MOBILE	126.		980	4350.	25.2	196.	870.
NAVAL, UNSHEL	150.		1400.	4350.	30.0	280.	870.
AIRBORNE, UNINHAB	228.		2000.	6000.	45.6	400.	1200.
MISSILE, LAUNCH	154.		1600.	7920.	30.7	320.	1580.

NON-OPERATING	ENVIRONMENTAL FACTORS									
	OPERATING					NON-OPERATING				
	G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>
JAN	1.0	3.2	3.2	20.	111.	125.	111.	159.	227.	181.
JANTX	1.0	3.7	3.7	24.	130.	146.	130.	185.	265.	212.

QUALITY FACTORS									
NON-OPERATING			OPERATING						
JAN	JANTX	JANTXV	JAN	JANTX	JANTXV				
1.0	.17	-							
			1.0	.2	.1				

PART CATEGORY: TRANSISTOR

DESCRIPTION: SILICON PNP

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
NON-OPERATING GROUND, FIXED						
JAN	*	*	8.82	11.9	-	10.5
JANTX	*	*	1.51	1.93	.75	62.9

ENVIRONMENT	FAILURE RATE IN FITS					
	JAN			JANTX		
	RANGE		RANGE			
LOW	BEST EST	HIGH	LOW	BEST EST	HIGH	
OPERATING						
GROUND, BENIGN	6.	42.	135.	1.2	8.4	27.
SPACE FLIGHT	6.	42.	135.	1.2	8.4	27.
GROUND, FIXED	36.	290.	1350.	7.2	58.	27.
AIRBORNE, INHAB	195.	1600.	7950.	39.	320.	1590.
NAVAL, SHELTERED	195.	1700.	7950.	39.	340.	1590.
GROUND, MOBILE	195.	1600.	7950.	39.	320.	1590.
NAVAL, UNSHEL	210.	2300.	6750.	42.	460.	1350.
AIRBORNE, UNINHAB	312.	3200.	15120	62.	640.	3020.
MISSILE, LAUNCH	288.	2500.	10800	58.	500.	2160.

ENVIRONMENTAL FACTORS											
NON-OPERATING				OPERATING							
	G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>	
JAN	1.0	4.8	4.8	33.	181.	193.	181.	261.	363.	283.	
JANTX	1.0	5.6	5.6	38.	212.	225.	212.	305.	424.	331.	

QUALITY FACTORS											
NON-OPERATING				OPERATING							
JAN	JANTX	JANTXV		JAN	JANTX	JANTXV					
1.0	.17	-		1.0	.2	.1					

\*See Transistor, Silicon, NPN

PART CATEGORY: TRANSISTOR

DESCRIPTION: GERMANIUM PNP

ENVIRONMENT	FAILURES	PART HOURS ( $10^6$ )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
NON-OPERATING GROUND, FIXED						
JAN	*	*	8.82	11.9	-	10.5
JANTX	*	*	1.51	1.93	.75	62.9

ENVIRONMENT	FAILURE RATE IN FITS					
	JAN			JANTX		
	RANGE		RANGE			
OPERATING	LCW	BEST EST	HIGH	LOW	BEST EST	HIGH
GROUND, BENIGN	4.5	42.	246.	.9	8.4	49.
SPACE FLIGHT	4.5	42.	246.	.9	8.4	49.
GROUND, FIXED	30.	410.	1230.	6.	82.	246.
AIRBORNE, INHAB	180.	2600.	8400.	36.	520.	1680.
NAVAL, SHELTERED	410.	3500.	10500.	82.	700.	700.
GROUND, MOBILE	180.	2600.	8400.	36.	520.	1680.
NAVAL, UNSHEL	410.	3500.**	10500.	82.	700.**	700.
AIRBORNE, UNINHAB	310.	2600.**	13440.	62.	520.**	2690.
MISSILE, LAUNCH	310.	4200.	13440.	62.	840.	2690.

ENVIRONMENTAL FACTORS											
NON-OPERATING				OPERATING							
G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>		
JAN	1.0	4.8	4.8	46.	295.	397.	295.	397.	295.	476.	
JANTX	1.0	5.6	5.6	54.	344.	464.	344.	464.	344.	556.	

QUALITY FACTORS											
NON-OPERATING				OPERATING							
JAN	JANTX	JANTXV		JAN	JANTX	JANTXV					
1.0	.17	-		1.0	.2	.1					

\*See Transistor, Silicon, NPN.

\*\*This value is valid only for electrical stress, S  $\leq 0.3$ .

## PART CATEGORY: TRANSISTOR

DESCRIPTION: GERMANIUM NPN

ENVIRONMENT	FAILURES	PART HOURS ( $10^6$ )	FAILURE RATE IN FITS				
			BEST ESTIMATE	90% CONFIDENCE	RANGE		
				LOW		HIGH	
<u>NON-OPERATING</u>							
GROUND, FIXED							
JAN	*	*	2.82	11.9	-	10.5	
JANTX	*	*	1.51	1.92	.75	62.9	

ENVIRONMENT	FAILURE RATE IN FITS						
	JAN			JANTX			
	RANGE	LOW	BEST EST	HIGH	LOW	BEST EST	HIGH
<u>OPERATING</u>							
GROUND, BENIGN	14.4	120.	720.	2.9	24.	144.	
SPACE FLIGHT	14.4	120.	720.	2.9	24.	144.	
GROUND, FIXED	108.	1100.	3600.	21.5	220.	720.	
AIRBORNE, INHAB	750.	7100.	21000.	150.	1420.	4200.	
NAVAL, SHELTERED	900.	9000.	27000.	180.	1800.	5400.	
GROUND, MOBILE	750.	7100.	21000.	150.	1420.	4200.	
NAVAL, UNSHEL	900.	9000**	27000.	180.	1800**	5400.	
AIRBORNE, UNINHAB	1200.	11000**	33600.	240.	2200**	6700.	
MISSILE, LAUNCH	1200.	11000.	33600.	240.	2200.	6700.	

ENVIRONMENTAL FACTORS											
NON-OPERATING				OPERATING							
	G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>T</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>	
JAN	1.0	14.	14.	125.	805.	1020	805	1020	1247	1247	
JANTX	1.0	16.	16.	146.	940.	1192	940	1192	1457	1457	

QUALITY FACTORS											
NON-OPERATING				OPERATING							
JAN	JANTX	JANTXV		JAN	JANTX	JANTXV					
1.0	.17	-		1.0	.2	.1					

See Transistor, Silicon, NPN

\*\*This value valid only for electrical stress, S &lt; 0.3

PART CATEGORY: TRANSISTOR

DESCRIPTION: FIELD EFFECT

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
NON-OPERATING GROUND, FIXED	-	-	5.75*	-	-	-
JAN	3	2616	1.15	2.55	-	-
JANTX						

ENVIRONMENT	FAILURE RATE IN FITS					
	JAN			JANTX		
	LOW	BEST EST	HIGH	LOW	BEST EST	HIGH
OPERATING						
GROUND, BENIGN	38.	76.	152.	7.6	15.2	30.
SPACE FLIGHT	38.	76.	152.	7.6	15.2	30.
GROUND, FIXED	220.	520.	760.	44.	104.	152.
AIRBORNE, INHAB	1100.	2700.	4400.	220.	540.	880.
NAVAL, SHELTERED	1100.	2900.	4400.	220.	580.	880.
GROUND, MOBILE	1100.	2700.	4400.	220.	540.	880.
NAVAL, UNSHEL	1300.	3900.	4400.	260.	780.	880.
AIRBORNE, UNINHAB	2000.	5600.	7000.	400.	1120.	1400.
MISSILE, LAUNCH	1800.	4400.	6400.	360.	880.	1300.

NON-OPERATING	ENVIRONMENTAL FACTORS									
	OPERATING									
	G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>
JAN	1.0	13.	13.	90.	470.	504.	470.	678.	974.	765.
JANTX	1.0	13.	13.	90.	470.	504.	470.	678.	974.	765.

QUALITY FACTORS									
NON-OPERATING			OPERATING						
JAN	JANTX	JANTXV	JAN	JANTX	JANTXV				
1.0	.2	-							
			1.0	.2	.1				

\* Extrapolated from Hi-Rel data using MIL-HDBK-217B quality factor.

## PART CATEGORY: TRANSISTOR

DESCRIPTION: UNIJUNCTION

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
					LOW	HIGH
NON-OPERATING GROUND, FIXED						
JAN	-	-	776.*	-	-	-
JANTX	-	-	388.*	-	-	-

ENVIRONMENT	FAILURE RATE IN FITS						
	JAN			JANTX			
	RANGE			RANGE			
OPERATING	LOW	BEST EST	HIGH	LOW	BEST EST	HIGH	
GROUND, BENIGN	88.	250.	880	18.	50.	176.	
SPACE FLIGHT	88.	250.	880	18.	50.	176.	
GROUND, FIXED	640.	1700.	5200	128.	340.	1040.	
AIRBORNE, INHAB	3400.	9400.	30000	680.	1880.	6000.	
NAVAL, SHELTERED	3800.	10000.	22000	760.	2000.	4400.	
GROUND, MOBILE	3400.	9400.	30000	680.	1880.	6000.	
NAVAL, UNSHEL	4800.	15000.	22000	960.	3000.	4400.	
AIRBORNE, UNINHAB	7000.	21000.	48000	1400.	4200.	9600.	
MISSILE, LAUNCH	5400.	15000.	48000	1100.	3000.	9600.	

ENVIRONMENTAL FACTORS											
NON-OPERATING			OPERATING								
	G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>	
JAN	1.0	.6	.6	4.	24.	26.	24.	54.	39.	39.	
JANTX	1.0	.6	.6	4.	24.	26.	24.	54.	39.	39.	

QUALITY FACTORS											
NON-OPERATING			OPERATING								
JAN	JANTX	JANTXV	JAN	JANTX	JANTXV						
1.0	.2	-	1.0	.2	.1						

\*Extrapolated from MIL-HDBK-217B minimum stress level.

## PART CATEGORY: TRANSISTOR

DESCRIPTION: MICROWAVE\*

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
NON-OPERATING GROUND, FIXED	-	-	117.6**	-	-	-
JAN	1	17	58.8	229.	-	-
JANTX						

ENVIRONMENT	FAILURE RATE IN FITS					
	JAN			JANTX		
	RANGE	LOW	BEST EST	HIGH	LOW	RANGE
OPERATING						
GROUND, BENIGN	60.	480.	1x10 <sup>5</sup>	30.	240.	77000
SPACE FLIGHT	60.	480.	1x10 <sup>5</sup>	30.	240.	77000
GROUND, FIXED	120.	960.	3x10 <sup>5</sup>	60.	480.	1x10 <sup>5</sup>
AIRBORNE, INHAB	600.	4800.	1x10 <sup>6</sup>	300.	2400.	8x10 <sup>5</sup>
NAVAL, SHELTERED	600.	4800.	1x10 <sup>6</sup>	300.	2400.	8x10 <sup>5</sup>
GROUND, MOBILE	600.	4800.	1x10 <sup>6</sup>	300.	2400.	8x10 <sup>5</sup>
NAVAL, UNSKEL	720.	5760.	2x10 <sup>6</sup>	360.	2880.	9x10 <sup>5</sup>
AIR, UNINHAB	960.	7680.	2x10 <sup>6</sup>	480.	3840.	1x10 <sup>6</sup>
MISSILE, LAUNCH	960.	7680.	2x10 <sup>6</sup>	480.	3840.	1x10 <sup>6</sup>

NON-OPERATING	ENVIRONMENTAL FACTORS									
	OPERATING									
	G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>
JAN	1.0	4.1	4.1	8.2	41.	41.	41.	49.	65.	65.
JANTX	1.0	4.1	4.1	8.2	41.	41.	41.	49.	65.	65.

QUALITY FACTORS									
NON-OPERATING			OPERATING						
JAN	JANTX	JANTXV	JAN	JANTX	JANTXV				
4	2	-				4	2	1	

\*Gold Refractory Metallization.

\*\*Extrapolated from Hi-Rel data using MIL-HDBK-217B quality factor.

PART CATEGORY: DIODE

DESCRIPTION: SILICON, GENERAL PURPOSE

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
<u>NON-OPERATING GROUND, FIXED</u>						
JAN	49	7834	6.25	7.55	184	12.4
JANTX	8	27254	.29	.48	-	.42

ENVIRONMENT	FAILURE RATE IN FITS					
	JAN			JANTX		
	RANGE		RANGE			
LOW	BEST EST	HIGH	LOW	BEST EST	HIGH	
<u>OPERATING</u>						
GROUND, BENIGN	5.6	17.	80.	1.1	3.4	16.
SPACE FLIGHT	5.6	17.	80.	1.1	3.4	16.
GROUND, FIXED	38.5	120.	450.	7.7	24.	90.
AIRBORNE, INHAB	210.	680.	2500.	42.	136.	500.
NAVAL, SHELTERED	230.	750.	2500.	46.	150.	500.
GROUND, MOBILE	210.	680.	2500.	42.	136.	500.
NAVAL, UNSHEL	290.	1100.	2500.	58.	220.	500.
AIRBORNE, UNINHAB	420.	1600.	5000.	84.	320.	800.
MISSILE, LAUNCH	340.	1100.	4000.	68.	220.	800.

ENVIRONMENTAL FACTORS										
NON-OPERATING			OPERATING							
	G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>
JAN	1.0	2.7	2.7	19.	109.	120.	109.	176.	256.	176.
JANTX	1.0	12.	12.	83.	469.	517.	469.	759.	1103	759.

QUALITY FACTORS										
NON-OPERATING			OPERATING							
JAN	JANTX	JANTXV	JAN	JANTX	JANTXV					
1.0	.05	-	1.0	.2	.1					

PART CATEGORY: DIODE

DESCRIPTION: GERMANIUM, GENERAL PURPOSE

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
					LOW	HIGH
NON-OPERATING GROUND, FIXED						
JAN	*	*	6.25	7.55	1.84	12.4
JANTX	*	*	.29	.48	-	.42

ENVIRONMENT	FAILURE RATE IN FITS					
	JAN			JANTX		
	RANGE	LOW	BEST EST	HIGH	LOW	BEST EST
<u>OPERATING</u>						
GROUND, BENIGN	6.6	22.	120.	1.3	4.4	24.
SPACE FLIGHT	6.6	22.	120.	1.3	4.4	24.
GROUND, FIXED	77.	260.	600.	15.4	52.	120.
AIRBORNE, INHAB	350.	1700.	3000.	70.	340.	600.
NAVAL, SHELTERED	530.	2500.	3000.	110.	500.	600.
GROUND, MOBILE	350.	1700.	3000.	70.	340.	600.
NAVAL, UNSHEL	1140.	2500**	2500.	230.	500**	500.
AIRBORNE, UNINHAB	1260.	2900**	2900.	250.	580**	580.
MISSILE, LAUNCH	560.	2700.	4800.	110.	540.	960.

NON-OPERATING	ENVIRONMENTAL FACTORS									
	OPERATING									
	G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>
JAN	1.0	3.5	3.5	42.	272.	400.	272.	400.	464.	432.
JANTX	1.0	15.	15.	179.	1172	1724	1172	1724	2000	1862.

QUALITY FACTORS									
NON-OPERATING			OPERATING						
JAN	JANTX	JANTXV	JAN	JANTX	JANTXV				
1.0	.05	-							
			1.0	.2	.1				

\*See Diodes, Silicon, General Purpose.

\*\*This value is valid only for electrical stress, S < 0.3

PART CATEGORY: DIODE

DESCRIPTION: ZENER AND AVALANCHE

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
NON-OPERATING GROUND, FIXED						
JAN	0	786	1.56*	3.12	-	-
JANTX	4	1775	1.56*	3.12	1.11	87.

ENVIRONMENT	FAILURE RATE IN FITS					
	JAN			JANTX		
	LOW	BEST EST	HIGH	LOW	BEST EST	HIGH
OPERATING						
GROUND, BENIGN	16.5	27.	75.	2.3	5.4	15.
SPACE FLIGHT	16.5	27.	75.	2.3	5.4	15.
GROUND, FIXED	95.	160.	375.	19.	32.	75.
AIRBORNE, INHAB	488.	850.	2250.	98.	170.	450.
NAVAL, SHELTERED	513.	910.	2250.	103.	180.	450.
GROUND, MOBILE	488.	850.	2250.	98.	170.	450.
NAVAL, UNSHEL	588.	1200.	2250.	118.	240.	450.
AIRBORNE, UNINHAB	900.	1800.	3600.	180.	360.	720.
MISSILE, LAUNCH	800.	1400.	3600.	160.	280.	720.

ENVIRONMENTAL FACTORS											
NON-OPERATING				OPERATING							
G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>		
JAN	1.0	17.	17.	103.	545.	583.	545.	769.	1154.	897.	
JANTX	1.0	3.5	3.5	21.	109.	115.	109.	154.	231.	179.	

QUALITY FACTORS											
NON-OPERATING				OPERATING							
JAN	JANTX	JANTXV		JAN	JANTX	JANTXV					
1.0	1.0	-		1.0	.2	.1					

\*Combination JAN/JANTX Data

PART CATEGORY: DIODE

DESCRIPTION: THYRISTOR

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS		
			BEST ESTIMATE	90% CONFIDENCE	RANGE
			LOW	HIGH	
<u>NON-OPERATING GROUND, FIXED</u>					
JAN	-	-	25.*	-	-
JANTX	-	-	5.**	-	-

ENVIRONMENT	FAILURE RATE IN FITS							
	JAN			JANTX				
	RANGE	LOW	BEST EST	HIGH	RANGE	LOW	BEST EST	HIGH
<u>OPERATING</u>								
GROUND, BENIGN	7.	23.	90.	1.4	4.6	18.		
SPACE FLIGHT	7.	23.	90.	1.4	4.6	18.		
GROUND, FIXED	50.	160.	480.	10.	32.	96.		
AIRBORNE, INHAB	270.	900.	2750.	54.	180.	550.		
NAVAL, SHELTERED	300.	1000.	2750.	60.	200.	550.		
GROUND, MOBILE	270.	900.	2750.	54.	180.	550.		
NAVAL, UNSHEL	410.	1400.	2750.	82.	280.	550.		
AIRBORNE, UNINHAB	600.	2000.	4400.	120.	400.	880.		
MISSILE, LAUNCH	400.	1400.	4400.	80.	280.	880.		

NON-OPERATING	ENVIRONMENTAL FACTORS									
	OPERATING									
	G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>
JAN	1.0	1.	1.	6.	36.	40.	36.	56.	80.	56.
JANTX	1.0	1.	1.	6.	36.	40.	36.	56.	80.	56.

QUALITY FACTORS									
NON-OPERATING			OPERATING						
JAN	JANTX	JANTXV	JAN	JANTX	JANTXV				
1.0	.2	-							
			1.0	.2	.1				

\*Extrapolated from MIL-HDBK-217B minimum stress level.

PART CATEGORY: DIODE

DESCRIPTION: SILICON MICROWAVE DETECTOR

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
NON-OPERATING GROUND, FIXED	-	-	24.5*	-	-	-
JAN	3	204.	14.7	32.6	-	-
JANTX						

ENVIRONMENT	FAILURE RATE IN FITS						
	JAN			JANTX			
	RANGE	LOW	BEST EST	HIGH	LOW	BEST EST	HIGH
OPERATING							
GROUND, BENIGN	140	190.	450	84	114.	270	
SPACE FLIGHT	140	190.	450	84	114.	270	
GROUND, FIXED	1540	2200.	5250	924	1320.	3150	
AIRBORNE, INHAB	7880	12000.	26250	4730	7200.	15750	
NAVAL, SHELTERED	8230	13000.	26250	4940	7800.	15750	
GROUND, MOBILE	7880	12000.	26250	4730	7200.	15750	
NAVAL, UNSHEL	8750	17000.	26250	5250	10200.	15750	
AIRBORNE, UNINHAB	13720	25000.	42000	8230	15000.	25200	
MISSILE, LAUNCH	31500	46000.	1x10 <sup>5</sup>	18900	27600.	63000	

NON-OPERATING	ENVIRONMENTAL FACTORS									
	OPERATING					NON-OPERATING				
	G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>
JAN	1.0	7.8	7.8	90.	490.	531.	490.	694.	1020.	1878.
JANTX	1.0	7.8	7.8	90.	490.	531.	400.	694.	1020.	1878.

QUALITY FACTORS									
NON-OPERATING			OPERATING						
JAN	JANTX	JANTXV	JAN	JANTX	JANTXV				
1.0	.6	-	1.0	.6	.3				

\*Extrapolated from JANTX data using MIL-HDBK-217B quality factor.

## PART CATEGORY: DIODE

DESCRIPTION: GERMANIUM MICROWAVE DETECTOR

ENVIRONMENT	FAILURES	PART HOURS ( $10^6$ )	FAILURE RATE IN FITS			RANGE
			BEST ESTIMATE	90% CONFIDENCE	LOW	
NON-OPERATING GROUND, FIXED					-	-
JAN	*	*	24.5	~	-	-
JANTX	*	*	14.7	32.6	-	-

ENVIRONMENT	FAILURE RATE IN FITS						
	JAN			JANTX			
	RANGE	LOW	BEST EST	HIGH	LOW	BEST EST	HIGH
OPERATING							
GROUND, BENIGN	290		410.	770	170	246.	460
SPACE FLIGHT	290		410.	770	170	246.	460
GROUND, FIXED	1730		5000*	5600	1040	3360*	3360**
AIRBORNE, INHAB	21000		35000*	35000	12600	21000*	21000**
NAVAL, SHELTERED			***			***	
GROUND, MOBILE	21000		35000*	35000	12600	21000*	21000**
NAVAL, UNSHEL			***			***	
AIRBORNE, UNINHAB			***			***	
MISSILE, LAUNCH			***			***	

ENVIRONMENTAL FACTOR											
NON-OPERATING				OPERATING							
G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>		
JAN	1.0	17.	17.	229.	1429.	***	1429.	***	***	***	***
JANTX	1.0	17.	17.	229.	1429.	***	1429.	***	***	***	***

QUALITY FACTORS											
NON-OPERATING				OPERATING							
JAN	JANTX	JANTXV		JAN	JANTX	JANTXV					
1.0	.6	-	/	1.0	.6	.3					

\*See Diode, Silicon Microwave Detector. \*\*This value valid only for electrical stress,  $S < 0.3$ . \*\*\*Not used in these environments.

PART CATEGORY: DIODE

DESCRIPTION: SILICON MICROWAVE MIXER

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
<u>NON-OPERATING GROUND, FIXED</u>						
JAN	*	*	24.5	-	-	-
JANTX	*	*	14.7	32.6	-	-

ENVIRONMENT	FAILURE RATE IN FITS					
	JAN			JANTX		
	LOW	BEST EST	HIGH	LOW	BEST EST	HIGH
<u>OPERATING</u>						
GROUND, BENIGN	193	250.	700	116	150.	420
SPACE FLIGHT	193	250.	700	116	150.	420
GROUND, FIXED	2100	3000.	7000	1260	1800.	4200
AIRBORNE, INHAB	10700	16000.	35000	6420	12800.	21000
NAVAL, SHELTERED	11000	17000.	35000	6600	10200.	21000
GROUND, MOBILE	10700	16000.	35000	6420	12800.	21000
NAVAL, UNSHEL	12100	23000.	35000	7260	13800.	21000
AIRBORNE, UNINHAB	18800	34000.	56000	11280	20400.	33600
MISSILE, LAUNCH	42700	64000.	1x10 <sup>5</sup>	25620	38400.	84000

ENVIRONMENTAL FACTORS											
NON-OPERATING			OPERATING								
	G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>	
JAN	1.0	10.	10.	122.	653.	694.	653.	939.	1388.	2612.	
JANTX	1.0	10.	10.	122.	653.	694.	653.	939.	1388.	2612.	

QUALITY FACTORS											
NON-OPERATING			OPERATING								
JAN	JANTX	JANTXV	JAN	JANTX	JANTXV						
1.0	.6	-	1.0	.6	.3						

\*See Diode: Silicon Microwave Detector

PART CATEGORY: DIODE

DESCRIPTION: GERMANIUM MICROWAVE MIXER

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
					LOW	HIGH
NON-OPERATING GROUND, FIXED						
JAN	*	*	24.5	-	-	-
JANTX	*	*	14.7	32.6	-	-

ENVIRONMENT	FAILURE RATE IN FITS						
	JAN			JANTX			
	RANGE	LOW	BEST EST	HIGH	LOW	BEST EST	HIGH
OPERATING							
GROUND, BENIGN		490	720.	1330	290	432.	800
SPACE FLIGHT		490	720.	1330	290	432.	800
GROUND, FIXED		5950	10000*	10000	3570	6000**	6000
AIRBORNE, INHAB		36750	61000*	61000	22000	36600**	36600
NAVAL, SHELTERED			***			***	
GROUND, MOBILE		36750	61000*	61000	22000	36600**	36600
NAVAL, UNSHEL			***			***	
AIRBORNE, UNINHAB			***			***	
MISSILE, LAUNCH			***			***	

NON-OPERATING	ENVIRONMENTAL FACTORS											
	OPERATING											
	G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>		
JAN	1.0	29.	29.	408.	2490.	***	2490.	***	***	***	***	
JANTX	1.0	29.	29.	408.	2490.	***	2490.	***	****	***	***	

QUALITY FACTORS											
NON-OPERATING				OPERATING							
JAN	JANTX	JANTXV		JAN	JANTX	JANTXV					
1.0	.6	-									

\*See Diode, Silicon Microwave Detector. \*\*This value valid only for electrical stress, S < 0.3. \*\*\*Not used in these environments.

PART CATEGORY: DIODE

DESCRIPTION: VARACTORS, STEP RECOVERY & TUNNEL

ENVIRONMENT	FAIL- URES	PART HOURS ( $10^6$ )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFI- DENCE	RANGE	
			LOW	HIGH		
NON-OPERATING GROUND, FIXED	- 0	- 4.0	523.* 105.*	- 577.	-	-

ENVIRONMENT	FAILURE RATE IN FITS					
	JAN			JANTX		
	LOW	BEST EST	HIGH	LOW	BEST EST	HIGH
<b>OPERATING</b>						
GROUND, BENIGN	120	240.	900	24	48.	180
SPACE FLIGHT	120	240.	900	24	48.	180
GROUND, FIXED	750	1500.	4500	150	300.	900
AIRBORNE, INHAB	4000	8100.	22500	800	1620.	4500
NAVAL, SHELTERED	4300	8800.	22500	860	1760.	4500
GROUND, MOBILE	4000	8100.	22500	800	1620.	4500
NAVAL, UNSHEL	5900	17000.	22500	1180	3400.	4500
AIRBORNE, UNINHAB	6000	12000.	36000	1200	2400.	7200
MISSILE, LAUNCH	6400	13000.	36000	1280	2600.	7200

NON-OPERATING	ENVIRONMENTAL FACTORS									
	OPERATING									
	G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>
JAN	1.0	.5	.5	3.	15.	17.	15.	33.	23.	25.
JANTX	1.0	.5	.5	3.	15.	17.	15..	33.	23.	25.

QUALITY FACTORS									
NON-OPERATING			OPERATING						
JAN	JANTX	JANTXV	JAN	JANTX	JANTXV				
1.0	.2	-	1.0	.2	.1				

\*Extrapolated from MIL-HDBK-217B minimum stress level.

PART CATEGORY: DIODES

DESCRIPTION: SILICON CONTROLLED RECTIFIER

ENVIRONMENT	FAIL- URES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS		
			BEST ESTIMATE	90% CONFID- ENCE	RANGE
LOW	HIGH				
<u>NON-OPERATING</u>					
GROUND, FIXED	- 1	- 509.2	9.8* 1.96	- 7.64	- -
JAN					
JANTX					

ENVIRONMENT	FAILURE RATE IN FITS					
	JAN			JANTX		
	LOW	BEST EST.	HIGH	LOW	BEST EST.	HIGH
<u>OPERATING</u>						
GROUND, BENIGN	8.4	26.	120.	1.7	5.1	24
SPACE FLIGHT	8.4	26.	120.	1.7	5.1	24
GROUND, FIXED	58.	180.	675.	12.	36.	135
AIRBORNE, INHAB	315.	1020.	3750.	63.	204.	750
NAVAL, SHELTERED	345.	1125.	3750.	69.	225.	750
GROUND, MOBILE	315.	1020.	3750.	63.	204.	750
NAVAL, UNSHEL.	435.	1650.	3750.	87.	330.	750
AIRBORNE, UNINHAB	630	2400.	7500.	126.	480.	120
MISSILE, LAUNCH	510	1650	6000.	102.	330.	120.

ENVIRONMENTAL FACTORS											
NON-OPERATING						OPERATING					
G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>		
JAN	1.0	2.7	2.7	18.	104.	115.	104.	168.	245.	168.	
JANTX	1.0	2.6	2.6	18.	104.	115.	104.	168.	245.	168.	

QUALITY FACTORS											
NON-OPERATING						OPERATING					
JAN	JANTX	JANTXV		JAN	JANTX	JANTXV					
1.0	.2	-		1.0	.2	.1					

\*Extrapolated from JANTX data based on MIL-HDEK-217B Quality Factor.

PART CATEGORY: TUBES, ELECTRONIC VACUUM

DESCRIPTION: RECEIVER, TRIODE, TETRODE, PENTODE, MIL-E-1

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
NON-OPERATING GROUND, FIXED MIL-STD HI-REL	12	983	12.0	18.1	-	-

ENVIRONMENT	FAILURE RATE IN FITS					
	MIL-STD			HI-REL		
	RANGE		RANGE			
OPERATING	LOW	BEST EST	HIGH	LOW	BEST EST	HIGH
GROUND, BENIGN		2500.				
SPACE FLIGHT		2500.				
GROUND, FIXED		5000.				
AIRBORNE, UNHAB		32500.				
NAVAL, SHELTERED		32500.				
GROUND, MOBILE		50000.				
NAVAL, UNSHEL.		50000.				
AIRBORNE, UNINHAB		50000.				
MISSILE, LAUNCH		400000.				

NON-OPERATING	ENVIRONMENTAL FACTORS									
	OPERATING									
	G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>
MIL-STD	1.0	208	208	417	2708	2708	4167	4167	4167	33333
HI-REL										

QUALITY FACTORS											
NON-OPERATING				OPERATING							
MIL-STD	HI-REL	LOWER GRADE	MIL-STD	HI-REL							

PART CATEGORY: TUBES, ELECTRONIC VACUUM

DESCRIPTION: RECEIVER, POWER RECTIFIER, MIL-E-1

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
NON-OPERATING GROUND, FIXED MIL-STD HI-REL	*	*	12.0	18.1	-	-

ENVIRONMENT	FAILURE RATE IN FITS						
	MIL-STD			HI-REL			
	RANGE		RANGE		LOW	BEST EST	HIGH
OPERATING							
GROUND, BENIGN		5000.					
SPACE FLIGHT		5000.					
GROUND, FIXED		10000.					
AIRBORNE, INHAB		65000.					
NAVAL, SHELTERED		65000.					
GROUND, MOBILE		100000.					
NAVAL, UNSHEL.		100000.					
AIRBORNE, UNINHAB		100000.					
MISSILE, LAUNCH		800000.					

NON-OPERATING	ENVIRONMENTAL FACTORS									
	OPERATING									
G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>	
MIL-STD 1.0	417	417	833	5417	5417	8333	8333	8333	8333	66667
HI-REL										

QUALITY FACTORS									
NON-OPERATING					OPERATING				
MIL-STD	HI-REL	LOWER GRADE	MIL-STD	HI-REL					

\*See Tubes, Receiver, Triode, Tetrode, Pentode

PART CATEGORY: TUBES, ELECTRONIC VACUUM

DESCRIPTION: KLYSTRON, LOW POWER (LOCAL OSCILLATOR)

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS		
			BEST ESTIMATE	90% CONFIDENCE	RANGE
			LOW	HIGH	
<u>NON-OPERATING</u>					
GROUND, FIXED MIL-STD HI-REL		SEE APPENDIX C			

ENVIRONMENT	FAILURE RATE IN FITS					
	MIL-STD			HI-REL		
	RANGE		RANGE			
	LOW	BEST EST.	HIGH	LOW	BEST EST.	HIGH
<u>OPERATING</u>						
GROUND, BENIGN						
SPACE FLIGHT						
GROUND, FIXED						
AIRBORNE, INHAB						
NAVAL, SHELTERED						
GROUND, MOBILE						
NAVAL, UNSHEL.						
AIRBORNE, UNINHAB						
MISSILE, LAUNCH						

NON-OPERATING	ENVIRONMENTAL FACTORS									
	OPERATING									
	G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>
MIL-STD										
HI-REL										

QUALITY FACTORS									
NON-OPERATING					OPERATING				
MIL-STD	HI-REL	L	M	P	R	S			

PART CATEGORY:	TUBES, ELECTRONIC VACUUM
DESCRIPTION:	KLYSTRON, HIGH POWER

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS		
			BEST ESTIMATE	90% CONFIDENCE	RANGE
LOW	HIGH				
<u>NON-OPERATING</u> GROUND, FIXED MIL-STD HI-REL		SEE APPENDIX C			

ENVIRONMENT	FAILURE RATE IN FITS					
	MIL-STD			HI-REL		
	RANGE			RANGE		
	LOW	BEST EST.	HIGH	LOW	BEST EST.	HIGH
<u>OPERATING</u> GROUND, BENIGN SPACE FLIGHT GROUND, FIXED AIRBORNE, INHAB NAVAL, SHELTERED GROUND, MOBILE NAVAL, UNSHEL. AIRBORNE, UNINHAB MISSILE, LAUNCH						

NON-OPERATING	ENVIRONMENTAL FACTORS									
	G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>
MIL-STD HI-REL										

QUALITY FACTORS									
NON-OPERATING					OPERATING				
MIL-STD	HI-REL	L	M	P	R	S			

PART CATEGORY: TUBES, ELECTRONIC VACUUM

DESCRIPTION: MAGNETRON, MEDIUM POWER <10 KILOWATTS (PEAK)

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS		
			BEST ESTIMATE	90% CONFIDENCE	RANGE
NON-OPERATING		SEE APPENDIX	C		

ENVIRONMENT	FAILURE RATE IN FITS					
	MIL-STD			HI-REL		
	RANGE		RANGE			
	LOW	BEST EST.	HIGH	LOW	BEST EST.	HIGH
<u>OPERATING</u>						
GROUND, BENIGN						
SPACE FLIGHT						
GROUND, FIXED						
AIRBORNE, INHAB						
NAVAL, SHELTERED						
GROUND, MOBILE						
NAVAL, UNSHEL.						
AIRBORNE, UNINHAB						
MISSILE, LAUNCH						

ENVIRONMENTAL FACTORS									
NON-OPERATING					OPERATING				
G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>
MIL-STD									
HI-REL									

QUALITY FACTORS									
NON-OPERATING					OPERATING				
MIL-STD	HI-REL				L	M	P	R	S

PART CATEGORY: TUBES, ELECTRONIC VACUUM

DESCRIPTION: MAGNETRON, HIGH POWER,  $> 10$  KILOWATTS (PEAK)

ENVIRONMENT	FAILURES	PART HOURS ( $10^6$ )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
NON-OPERATING		SEE APPENDIX C			LOW	HIGH

ENVIRONMENT	FAILURE RATE IN FITS					
	MIL-STD			HI-REL		
	RANGE			RANGE		
	LOW	BEST EST.	HIGH	LOW	BEST EST.	HIGH
<u>OPERATING</u>						
GROUND, BENIGN						
SPACE FLIGHT						
GROUND, FIXED						
AIRBORNE, INHAB						
NAVAL, SHELTERED						
GROUND, MOBILE						
NAVAL, UNSHEL.						
AIRBORNE, UNINHAB						
MISSILE, LAUNCH						

ENVIRONMENTAL FACTORS									
NON-OPERATING					OPERATING				
<u>G<sub>F</sub></u>	<u>G<sub>B</sub></u>	<u>S<sub>F</sub></u>	<u>G<sub>F</sub></u>	<u>A<sub>I</sub></u>	<u>N<sub>S</sub></u>	<u>G<sub>M</sub></u>	<u>N<sub>U</sub></u>	<u>A<sub>U</sub></u>	<u>M<sub>L</sub></u>
MIL-STD									
HI-REL									

QUALITY FACTORS									
NON-OPERATING					OPERATING				
<u>MIL-STD</u>	<u>HI-REL</u>	<u>L</u>	<u>M</u>	<u>F</u>	<u>R</u>	<u>S</u>	<u>L</u>	<u>M</u>	<u>F</u>

PART CATEGORY: TUBES, ELECTRONIC VACUUM

DESCRIPTION: TWT, PEAK POWER <100 WATTS

ENVIRONMENT	FAILURES	PART HOURS ( $10^6$ )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE LOW	RANGE HIGH
<u>NON-OPERATING</u> GROUND, FIXED MIL-STD HI-REL		SEE APPENDIX C				

ENVIRONMENT	FAILURE RATE IN FITS					
	MIL-STD			HI-REL		
	RANGE		RANGE			
	LOW	BEST EST.	HIGH	LOW	BEST EST.	HIGH
<u>OPERATING</u> GROUND, BENIGN SPACE FLIGHT GROUND, FIXED AIRBORNE, INHAB NAVAL, SHELTERED GROUND, MOBILE NAVAL, UNSHEL. AIRBORNE, UNINHAB MISSILE, LAUNCH						

NON-OPERATING	ENVIRONMENTAL FACTORS									
	G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>
MIL-STD HI-REL										

QUALITY FACTORS									
NON-OPERATING					OPERATING				
MIL-STD	HI-REL	L	M	P	R	S			

PART CATEGORY: TUBES ELECTRONIC VACUUM

DESCRIPTION: TWT, PEAK POWER  $\geq$  100 WATTS,  $\leq$  10000 WATTS

ENVIRONMENT	FAILURES	PART HOURS ( $10^6$ )	FAILURE RATE IN FITS		
			BEST ESTIMATE	90% CONFIDENCE	RANGE
NON-OPERATING		SEE APPENDIX	C		

ENVIRONMENT	FAILURE RATE IN FITS					
	MIL-STD			HI-REL		
	RANGE		RANGE			
	LOW	BEST EST.	HIGH	LOW	BEST EST.	HIGH
OPERATING						
GROUND, BENIGN						
SPACE FLIGHT						
GROUND, FIXED						
AIRBORNE, INHAB						
NAVAL, SHELTERED						
GROUND, MOBILE						
NAVAL, UNSHEL.						
AIRBORNE, UNINHAB						
MISSILE, LAUNCH						

NON-OPERATING	ENVIRONMENTAL FACTORS								
	OPERATING								
<u>G<sub>F</sub></u>	<u>G<sub>B</sub></u>	<u>S<sub>F</sub></u>	<u>G<sub>F</sub></u>	<u>A<sub>I</sub></u>	<u>N<sub>S</sub></u>	<u>G<sub>M</sub></u>	<u>N<sub>U</sub></u>	<u>A<sub>U</sub></u>	<u>M<sub>L</sub></u>
MIL-STD HI-REL									

QUALITY FACTORS									
NON-OPERATING					OPERATING				
<u>MIL-STD</u>	<u>HI-REL</u>	<u>L</u>	<u>M</u>	<u>P</u>	<u>R</u>	<u>S</u>	<u>L</u>	<u>M</u>	<u>P</u>

PART CATEGORY: TUBES, ELECTRONIC VACUUM

DESCRIPTION: TRANSMITTING, TRIODE, MIL-E-1

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS		
			BEST ESTIMATE	90% CONFIDENCE	RANGE
			LOW	HIGH	
<u>NON-OPERATING</u>			TBD		
GROUND, FIXED MIL-STD HI-REL					

ENVIRONMENT	FAILURE RATE IN FITS					
	MIL-STD			HI-REL		
	RANGE		RANGE			
	LOW	BEST EST.	HIGH	LOW	BEST EST.	HIGH
<u>OPERATING</u>						
GROUND, BENIGN		37500.				
SPACE FLIGHT		37500.				
GROUND, FIXED		75000.				
AIRBORNE, INHAB		488000.				
NAVAL, SHELTERED		488000.				
GROUND, MOBILE		750000.				
NAVAL, UNSHEL.		750000.				
AIRBORNE, UNINHAB		750000.				
MISSILE, LAUNCH		6x10 <sup>6</sup>				

NON-OPERATING	ENVIRONMENTAL FACTORS								
	OPERATING								
<u>G<sub>F</sub></u>	<u>G<sub>B</sub></u>	<u>S<sub>F</sub></u>	<u>G<sub>F</sub></u>	<u>A<sub>I</sub></u>	<u>N<sub>S</sub></u>	<u>G<sub>M</sub></u>	<u>N<sub>U</sub></u>	<u>A<sub>U</sub></u>	<u>M<sub>L</sub></u>
MIL-STD									

QUALITY FACTORS									
NON-OPERATING					OPERATING				
<u>MIL-STD</u>	<u>HI-REL</u>	<u>L</u>	<u>M</u>	<u>P</u>	<u>R</u>	<u>S</u>	<u>L</u>	<u>M</u>	<u>P</u>

PART CATEGORY: TUBE, ELECTRONIC VACUUM

DESCRIPTION: TRANSMITTING, TETRODE & PENTODE

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS		
			BEST ESTIMATE	90% CONFIDENCE	RANGE
			LOW	HIGH	
<u>NON-OPERATING</u>			TBD		
GROUND, FIXED MIL-STD HI-REL					

ENVIRONMENT	FAILURE RATE IN FITS					
	MIL-STD			HI-REL		
	RANGE			RANGE		
	LOW	BEST EST.	HIGH	LOW	BEST EST.	HIGH
<u>OPERATING</u>						
GROUND, BENIGN		50000.				
SPACE FLIGHT		50000.				
GROUND, FIXED		100000.				
AIRBORNE, INHAB		650000.				
NAVAL, SHELTERED		650000.				
GROUND, MOBILE		1x10 <sup>6</sup>				
NAVAL, UNSHEL.		1x10 <sup>6</sup>				
AIRBORNE, UNINHAB		1x10 <sup>6</sup>				
MISSILE, LAUNCH		8x10 <sup>6</sup>				

NON-OPERATING	ENVIRONMENTAL FACTORS									
	OPERATING									
	G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>
MIL-STD										

QUALITY FACTORS									
NON-OPERATING					OPERATING				
MIL-STD	HI-REL	L	M	P	R	S			

PART CATEGORY: RESISTOR

DESCRIPTION: INSULATED FIXED COMPOSITION, MIL-R-39008, Style  
RCR

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS		
			BEST ESTIMATE	90% CONFIDENCE	RANGE
LOW	HIGH				
<u>NON-OPERATING</u> GROUND, FIXED MIL-STD HI-REL	0	15065.	N/A <0.066	0.15	- -

ENVIRONMENT	FAILURE RATE IN FITS					
	MIL-STD			HI-REL		
	RANGE			RANGE		
	LOW	BEST EST.	HIGH	LOW	BEST EST.	HIGH
<u>OPERATING</u> GROUND, BENIGN SPACE FLIGHT GROUND, FIXED AIRBORNE, INHAB NAVAL, SHELTERED GROUND, MOBILE NAVAL, UNSHEL. AIRBORNE, UNINHAB MISSILE, LAUNCH				.2 .2 1.0 2.0 3.0 3.5 9.0 8.0 8.0	.45 .45 2.0 4.8 7.7 8.5 21. 18. 18.	2.3 2.3 16. 32. 49. 56. 109. 118. 120.

ENVIRONMENTAL FACTORS									
NON-OPERATING					OPERATING				
G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>
MIL-STD									
HI-REL	1.0	6.8	6.8	30.	73.	117.	129.	318.	273.

QUALITY FACTORS									
NON-OPERATING					OPERATING				
MIL-STD	HI-REL				L	M	P	R	S
1.0	.3				-	1.0	.3	.1	.01

## PART CATEGORY: RESISTOR

DESCRIPTION: INSULATED FIXED COMPOSITION, MIL-R-11, Style RC

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
NON-OPERATING GROUND, FIXED MIL-STD HI-REL	2	9131	0.22 N/A	0.58	-	0.45

ENVIRONMENT	FAILURE RATE IN FITS						
	MIL-STD			HI-REL			
	RANGE		RANGE		LOW	BEST EST	HIGH
OPERATING							
GROUND, BENIGN	1.	2.3	18.			N/A	
SPACE FLIGHT	1.	2.3	18.				
GROUND, FIXED	4.	10.	65.				
AIRBORNE, INHAB	10.	24.	160.				
NAVAL, SHELTERED	18.	39.	300.				
GROUND, MOBILE	18.	43.	300.				
NAVAL, UNSHEL.	45.	110.	550.				
AIRBORNE, UNINHAB	40.	90.	600.				
MISSILE, LAUNCH	38.	90.	600.				

NON-OPERATING	ENVIRONMENTAL FACTORS									
	OPERATING									
G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>	
MIL-STD	1.0	10.	10.	45.	109.	177.	195.	500.	409.	409.
HI-REL										

QUALITY FACTORS									
NON-OPERATING					OPERATING				
MIL-STD	HI-REL	L	M	P	R	S			
1.0	.3								

PART CATEGORY: RESISTOR

DESCRIPTION: FIXED FILM (INSULATED), MIL-R-39017, Style RLR

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
NON-OPERATING					LOW	HIGH
GROUND, FIXED MIL-STD HI-REL	1	57303.	N/A 0.017	0.07	-	0.08

ENVIRONMENT	FAILURE RATE IN FITS					
	MIL-STD			HI-REL		
	RANGE			RANGE		
	LOW	BEST EST.	HIGH	LOW	BEST EST.	HIGH
<u>OPERATING</u>						
GROUND, BENIGN				1.5	2.4	11.
SPACE FLIGHT				1.5	2.4	11.
GROUND, FIXED				9.	15.	73.
AIRBORNE, INHAB				10.	20.	78.
NAVAL, SHELTERED				14.	26.	103.
GROUND, MOBILE				19.	37.	145.
NAVAL, UNSHEL.				31.	52.	213.
AIRBORNE, UNINHAB				33.	54.	230.
MISSILE, LAUNCH				67.	110.	508.

NON-OPERATING	ENVIRONMENTAL FACTORS									
	OPERATING									
	G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>
MIL-STD										
HI-REL	1.0	141	141	882	1176	1529	2176	3059	3176	6471

QUALITY FACTORS									
NON-OPERATING					OPERATING				
MIL-STD	HI-REL	L	M	P	R	S			
1.0	.15	-	1.0	.3	.1	.01			

PART CATEGORY: RESISTOR

DESCRIPTION: FIXED FILM (INSULATED), MIL-R-22684, Style RL

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS		
			BEST ESTIMATE	90% CONFIDENCE	RANGE
			LOW	HIGH	
<u>NON-OPERATING</u> GROUND, FIXED MIL-STD HI-REL	1	9237.	0.11 N/A	0.42	- 0.19

ENVIRONMENT	FAILURE RATE IN FITS					
	MIL-STD			HI-REL		
	RANGE			RANGE		
OPERATING	LOW	BEST EST	HIGH	LOW	BEST EST	HIGH
GROUND, BENIGN	8.	13.	60.		N/A	
SPACE FLIGHT	24.	13.	60.			
GROUND, FIXED	48.	75.	338.			
AIRBORNE, INHAB	52.	100.	390.			
NAVAL, SHELTERED	68.	130.	510.			
GROUND, MOBILE	102.	190.	765.			
NAVAL, UNSHEL.	140.	260.	1080.			
AIRBORNE, UNINHAB	150.	270.	1160.			
MISSILE, LAUNCH	300.	550.	2230.			

NON-OPERATING	ENVIRONMENTAL FACTORS									
	OPERATING					NON-OPERATING				
G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>	
MIL-STD	1.0	118	118	682	909	1182	1727	2364	2455	2727
HI-REL										

QUALITY FACTORS									
NON-OPERATING					OPERATING				
MIL-STD	HI-REL	L	M	P	R	S			
1.0	.15								

PART CATEGORY: RESISTOR

DESCRIPTION: FIXED FILM, MIL-R-55182, Style RNR & RNC and  
MIL-R-10509, Style Rn

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
NON-OPERATING GROUND, FIXED MIL-STD HI-REL	*	*	0.11 0.017	0.42 0.07	-	0.19 0.08

ENVIRONMENT	FAILURE RATE IN FITS					
	MIL-STD			HI-REL		
	LOW	BEST EST	HIGH	LOW	BEST EST	HIGH
OPERATING						
GROUND, BENIGN	1.7	2.8	12.3	.17	.28	1.23
SPACE FLIGHT	1.7	2.8	12.3	.17	.28	1.23
GROUND, FIXED	9.5	17.	81.2	.95	1.7	8.12
AIRBORNE, INHAB	13.5	23.	115.	1.35	2.3	11.5
NAVAL, SHELTERED	18.	30.	143.	1.8	3.0	14.3
GROUND, MOBILE	25.	42.	202.	2.5	4.2	20.2
NAVAL, UNSHEL.	34.	62.	302.	3.4	6.2	30.2
AIRBORNE, UNINHAB	36.	63.	302.	3.6	6.3	30.2
MISSILE, LAUNCH	68.	120.	585.	6.8	12.	58.5

ENVIRONMENTAL FACTORS										
NON-OPERATING					OPERATING					
G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>J</sub>	A <sub>U</sub>	M <sub>L</sub>	
MIL-STD	1.0	25.	25.	154.	209.	273.	382.	564.	573.	1091.
HI-REL	1.0	16.	16.	100.	135.	176.	247.	365.	371.	706.

QUALITY FACTORS									
NON-OPERATING					OPERATING				
MIL-STD	HI-REL		L	M	P	R	S		
			-	1.0	.3	.1	.01		

\*See Resistor, Fixed Film (Insulated), MIL-R-39017, Style RLR.  
& MIL-R-22684, Style RL

PART CATEGORY: RESISTOR

DESCRIPTION: POWER FILM, MIL-R-11804, Style RD/P

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
NON-OPERATING GROUND, FIXED MIL-STD HI-REL	-	-	700.* 280.*	- -	- -	- -

ENVIRONMENT	FAILURE RATE IN FITS						
	MIL-STD			HI-REL			
	RANGE	LOW	BEST EST	HIGH	LOW	BEST EST	HIGH
OPERATING							
GROUND, BENIGN	150.		180.	940	60.	72.	380
SPACE FLIGHT	150.		180.	940	60.	72.	380
GROUND, FIXED	790.		960.	4900	320.	384.	2000
AIRBORNE, INHAB	1000.		1300.	6300	400.	520.	2500
NAVAL, SHELTERED	1200.		1500.	7000	480.	600.	2800
GROUND, MOBILE	1900.		2300.	11200	760.	920.	4500
NAVAL, UNSHEL.	2200.		2800.	12600	880.	1100.	5000
AIRBORNE, UNINHAB	2500.		3100.	14300	1000.	1200.	5700
MISSILE, LAUNCH	5500.		6800.	33200	2200.	2700.	13300

ENVIRONMENTAL FACTORS										
NON-OPERATING			OPERATING							
G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>	
MIL-STD	1.0	.3	.3	1.	2.	2.	3.	4.	4.	10.
HI-REL	1.0	.3	.3	1.	2.	2.	3.	4.	4.	10.

QUALITY FACTORS										
NON-OPERATING					OPERATING					
MIL-STD	HI-REL	LOWER GRADE	MIL-STD	HI-REL						
1.0	.4	3.0	1.0	.4						

\*Extrapolated from MIL-HDBK-217B minimum stress level.

PART CATEGORY: RESISTOR

DESCRIPTION: FIXED, WIREWOUND (ACCURATE), MIL-R-39005, Style RDR

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE LOW	RANGE HIGH
<u>NON-OPERATING</u>						
GROUND, FIXED MIL-STD HI-REL	1	5064.	N/A 0.20	0.77	-	0.82

ENVIRONMENT	FAILURE RATE IN FITS					
	MIL-STD			HI-REL		
	RANGE		RANGE			
	LOW	BEST EST.	HIGH	LOW	BEST EST.	HIGH
<u>OPERATING</u>						
GROUND, BENIGN				5.1	8.5	110.
SPACE FLIGHT				5.1	3.5	110.
GROUND, FIXED				32.	56.	750.
AIRBORNE, INHAB				88.	50.	2100.
NAVAL, SHELTERED				110.	180.	2500.
GROUND, MOBILE				110.	190.	2500.
NAVAL, UNSHEL.				150.	260.	3700.
AIRBORNE, UNINHAB				190.	320.	4800.
MISSILE, LAUNCH				410.	600.	10000.

NON-OPERATING	ENVIRONMENTAL FACTORS									
	OPERATING									
	G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>f</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>
MIL-STD										
HI-REL	1.0	43	43	280	750	900	950	1300	1600	3400

QUALITY FACTORS											
NON-OPERATING						OPERATING					
MIL-STD	HI-REL					L	M	P	R	S	
1.0	.17					-	1.0	.3	.1	.01	

PART CATEGORY: RESISTOR

DESCRIPTION: FIXED, WIREWOUND (ACCURATE), MJL-R-93, Style RB

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			RANGE	
			BEST ESTIMATE	90% CONFIDENCE	LOW	HIGH	
NON-OPERATING GROUND, FIXED MIL-STD HI-REL	2	1675.	1.19 N/A	3.18	-	5.32	

ENVIRONMENT	FAILURE RATE IN FITS					
	MIL-STD			HI-REL		
	RANGE		RANGE			
OPERATING	LOW	BEST EST	HIGH	LOW	BEST EST	HIGH
GROUND, BENIGN	25.	43.	580		N/A	
SPACE FLIGHT	25.	43.	580			
GROUND, FIXED	160.	280.	3700			
AIRBORNE, INHAB	440.	750.	10000			
NAVAL, SHELTERED	530.	900.	12000			
GROUND, MOBILE	590.	950.	14000			
NAVAL, UNSHEL.	740.	1300.	19000			
AIRBORNE, UNINHAB	960.	1600.	24000			
MISSILE, LAUNCH	2100.	3400.	49000			

NON-OPERATING	ENVIRONMENTAL FACTORS									
	OPERATING									
G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>	
MIL-STD	1.0	36.	36.	235.	630.	756.	798.	1092	1345	2857
HI-REL										

QUALITY FACTORS										
NON-OPERATING					OPERATING					
MIL-STD	HI-REL	L	M	P	R	S				
1.0	.17									

PART CATEGORY: RESISTOR

DESCRIPTION: FIXED, WIREWOUND (POWER TYPE), MIL-R-39007, Style RWR

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
<u>NON-OPERATING</u> GROUND, FIXED MIL-STD HI-REL	*	*	N/A 0.20*	0.77	-	0.82

ENVIRONMENT	FAILURE RATE IN FITS					
	MIL-STD			HI-REL		
	RANGE			RANGE		
	LOW	BEST EST.	HIGH	LOW	BEST EST.	HIGH
<u>OPERATING</u> GROUND, BENIGN SPACE FLIGHT GROUND, FIXED AIRBORNE, INHAB NAVAL, SHELTERED GROUND, MOBILE NAVAL, UNSHEL. AIRBORNE, UNINHAB MISSILE, LAUNCH				3.6 3.6 13. 25. 31. 42. 59. 86. 130.	9. 9. 33. 66. 85. 110. 160. 260. 330.	38. 38. 110. 220. 290. 370. 460. 580. 1100.

ENVIRONMENTAL FACTORS									
NON-OPERATING					OPERATING				
G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>
MIL-STD									
HI-REL	1.0	45.	45.	165.	330.	425.	550.	800.	1300.
									1650.

QUALITY FACTORS									
NON-OPERATING					OPERATING				
MIL-STD	HI-REL				L	M	P	R	S
1.0	.17								

\*See Resistor, Fixed, Wirewound (Accurate), MIL-R-39005, Style RPF

PART CATEGORY: RESISTOR

DESCRIPTION: FIXED, WIREWOUND (POWER TYPE), MIL-R-26, Style RW

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
NON-OPERATING GROUND, FIXED MIL-STD HI-REL	*	*	1.49*	3.18	-	5.32

ENVIRONMENT	FAILURE RATE IN FITS						
	MIL-STD			HI-REL			
	RANGE		RANGE		LOW	BEST EST	HIGH
OPERATING							
GROUND, BENIGN	18.	46.	180.			N/A	
SPACE FLIGHT	18.	46.	180.				
GROUND, FIXED	63.	170.	540.				
AIRBORNE, INHAB	130.	330.	1100.				
NAVAL, SHELTERED	160.	430.	1400.				
GROUND, MOBILE	210.	550.	1800.				
NAVAL, UNSHEL.	270.	800.	2100.				
AIRBORNE, UNINHAB	430.	1300.	2900.				
MISSILE, LAUNCH	630.	1700.	5600.				

ENVIRONMENTAL FACTORS											
NON-OPERATING				OPERATING							
G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>		
MIL-STD	1.0	39	39	143	277	361	462	672	1092	1429	
HI-REL											

QUALITY FACTORS											
NON-OPERATING						OPERATING					
MIL-STD	HI-REL					L	M	P	R	S	
1.0	.17										

\* See Resistor, Fixed, Wirewound, (Accurate), MIL-R-93, Style RB.

**PART CATEGORY: RESISTOR**

**DESCRIPTION: FIXED, WIREWOUND (POWER TYPE, CHASSIS MOUNTED),  
MIL-R-39009, Style RER**

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS		
			BEST ESTIMATE	90% CONFIDENCE	RANGE
			LOW	HIGH	
<b>NON-OPERATING</b>					
GROUND, FIXED MIL-STD HI-REL	*	*	N/A 0.20	0.77	- 0.82

ENVIRONMENT	FAILURE RATE IN FITS					
	MIL-STD			HI-REL		
	RANGE			RANGE		
	LOW	BEST EST.	HIGH	LOW	BEST EST.	HIGH
<b>OPERATING</b>						
GROUND, BENIGN				6.1	16.	70.
SPACE FLIGHT				6.1	16.	70.
GROUND, FIXED				22.	62	220.
AIRBORNE, INHAB				44.	130.	450.
NAVAL, SHELTERED				56.	160.	610.
GROUND, MOBILE				74.	220.	740.
NAVAL, UNSHEL.				99.	300.	850.
AIRBORNE, UNINHAB				110.	340.	930.
MISSILE, LAUNCH				220.	660.	2200.

NON-OPERATING	ENVIRONMENTAL FACTORS									
	OPERATING									
	G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>
MIL-STD										
HI-REL	1.0	80	80	310	650	300	1100	1500	1700	3300

QUALITY FACTORS									
NON-OPERATING					OPERATING				
MIL-STD	HI-REL		L	M	P	R	S		
1.0	.17		-	1.0	.3	.1	.01		

\*See Resistor, Fixed, Wirewound (Accurate), MIL-R-39005, Style RER.

PART CATEGORY: RESISTOR

DESCRIPTION: FIXED, WIREWOUND (POWER TYPE, CHASSIS MOUNTED),  
MIL-R-18546, Style RE

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
NON-OPERATING GROUND, FIXED MIL-STD HI-REL	*	*	1.19* N/A	3.18	-	5.32

ENVIRONMENT	FAILURE RATE IN FITS					
	MIL-STD			HI-REL		
	RANGE			RANGE		
OPERATING	LOW	BEST EST	HIGH	LOW	BEST EST	HIGH
GROUND, BENIGN	30.	80.	350		N/A	
SPACE FLIGHT	30.	80.	350			
GROUND, FIXED	110.	310.	1100			
AIRBORNE, INHAB	220.	650.	2200			
NAVAL, SHELTERED	280.	800.	3000			
GROUND, MOBILE	370.	1100.	3700			
NAVAL, UNSHEL.	490.	1500.	4200			
AIRBORNE, UNINHAB	540.	1700.	4600			
MISSILE, LAUNCH	1100.	3300.	11200			

ENVIRONMENTAL FACTORS											
NON-OPERATING				OPERATING							
G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>		
MIL-STD	1.0	67	67	261	546	672	924	1261	1429	2773	
HI-REL											

QUALITY FACTORS											
NON-OPERATING				OPERATING							
MIL-STD	HI-REL			L	M	P	R	S			
1.0	.17										

\*See Resistor, Fixed, Wirewound (Accurate), MIL-R-93, Style RB

PART CATEGORY: RESISTOR

DESCRIPTION: THERMISTOR, MIL-STD and MIL-T-23648, Style RTH

ENVIRONMENT	FAIL- URES	PART HOURS ( $10^6$ )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFI- DENCE	RANGE	
			LOW	HIGH		
NON-OPERATING						
GROUND, FIXED						
MIL-STD	3	22.5	133.3	236.	31.6	-
HI-REL	0	59.1	<16.9	39.1	-	-

ENVIRONMENT	FAILURE RATE IN FITS						
	BEAD TYPE			DISK TYPE			
	RANGE	LOW	BEST EST	HIGH	LOW	BEST EST	HIGH
OPERATING							
GROUND, BENIGN			21.			65.	
SPACE FLIGHT			21.			65.	
GROUND, FIXED			100.			310.	
AIRBORNE, INHAB			250.			750.	
NAVAL, SHELTERED			300.			900.	
GROUND, MOBILE			520.			1600.	
NAVAL, UNSHEL.			400.			1200.	
AIRBORNE, UNINHAB			340.			1000.	
MISSILE, LAUNCH			1200.			3600.	

NON-OPERATING	ENVIRONMENTAL FACTORS									
	OPERATING									
G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>	
BEAD TYPE 1.0	.2	.2	.8	1.9	2.3	3.9	3.0	2.6	9.0	
DISK TYPE 1.0	3.8	3.8	18.	44.	53.	95.	71.	59.	213.	

QUALITY FACTORS										
NON-OPERATING					OPERATING					
MIL-STD	HI-REL	L	M	P	R	S				

PART CATEGORY: RESISTOR

DESCRIPTION: VARIABLE, WIREWOUND (LEAD SCREW-ACTUATED),  
MIL-R-39015, Style RTR

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS		
			BEST ESTIMATE	90% CONFIDENCE	RANGE
			LOW	HIGH	
<u>NON-OPERATING</u>					
GROUND, FIXED MIL-STD HI-REL	2	539.	N/A 3.71	9.87	- 43.5

ENVIRONMENT	FAILURE RATE IN FITS					
	MIL-STD			HI-REL		
	RANGE			RANGE		
	LOW	BEST EST.	HIGH	LOW	BEST EST.	HIGH
<u>OPERATING</u>						
GROUND, BENIGN				11.	18.	130.
SPACE FLIGHT				11.	18.	130.
GROUND, FIXED				42.	66.	500.
AIRBORNE, INHAB				84.	140.	1100.
NAVAL, SHELTERED				98.	170.	1300.
GROUND, MOBILE				110.	180.	1300.
NAVAL, UNSHEL.				180.	300.	2300.
AIRBORNE, UNINHAB				200.	340.	2400.
MISSILE, LAUNCH				840.	1400.	11000.

NON-OPERATING	ENVIRONMENTAL FACTORS									
	OPERATING									
	G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>
MIL-STD										
HI-REL	1.0	4.9	4.9	18.	38.	46.	49.	81.	92.	377.

QUALITY FACTORS									
NON-OPERATING					OPERATING				
MIL-STD	HI-REL		L	M	P	R	S		
1.0	1.0		-	1.0	.3	.1	.03		

PART CATEGORY: RESISTOR

DESCRIPTION: VARIABLE, WIREWOUND (LEAD SCREW ACTUATED)  
MIL-R-27208, Style RT

ENVIRONMENT	FAIL- URES	PART HOURS ( $10^6$ )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFI- DENCE	RANGE	
			LOW	HIGH		
NON-OPERATING GROUND, FIXED MIL-STD HI-REL	2	528.	3.79 N/A	10.1	1.94	90.9

ENVIRONMENT	FAILURE RATE IN FITS						
	MIL-STD			HI-REL			
	RANGE	LOW	BEST EST	HIGH	LOW	BEST EST	HIGH
<u>OPERATING</u>							
GROUND, BENIGN	55.	90.	640.		N/A		
SPACE FLIGHT	55.	90.	640.				
GROUND, FIXED	210.	330.	2500.				
AIRBORNE, INHAB	420.	700.	5400.				
NAVAL, SHELTERED	490.	850.	6300.				
GROUND, MOBILE	560.	900.	6700.				
NAVAL, UNSHEL.	850.	1500.	11000.				
AIRBORNE, UNINHAB	960.	1700.	12000.				
MISSILE, LAUNCH	5100.	9000.	68000.				

NON-OPERATING	ENVIRONMENTAL FACTORS									
	OPERATING									
	G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>
MIL-STD	1.0	24.	24.	87.	185.	224.	237.	396.	449.	2375
HI-REL										

QUALITY FACTORS										
NON-OPERATING					OPERATING					
MIL-STD	HI-REL	L	M	P	R	S				
1.0	1.0									

PART CATEGORY: RESISTOR

DESCRIPTION: PRECISION WIREWOUND POTENTIOMETER, MIL-R-12934,  
Style PR

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
NON-OPERATING GROUND, FIXED MIL-STD HI-REL	0	119.	<8.4 N/A	19.4	-	-

ENVIRONMENT	FAILURE RATE IN FITS						
	MIL-STD			HI-REL			
	RANGE	LOW	BEST EST	HIGH	LOW	BEST EST	HIGH
OPERATING GROUND, BENIGN	340.		430.	5x10 <sup>4</sup>			
SPACE FLIGHT	340.		430.	5x10 <sup>4</sup>			
GROUND, FIXED	2100.		2700.	3x10 <sup>5</sup>			
AIRBORNE, INHAB	4100.		5800.	7x10 <sup>5</sup>			
NAVAL, SHELTERED	4600.		6100.	8x10 <sup>5</sup>			
GROUND, MOBILE	4100.		5800.	7x10 <sup>5</sup>			
NAVAL, UNSHEL.	6300.		9000.	1x10 <sup>6</sup>			
AIRBORNE, UNINHAB	7900.		11000.	1x10 <sup>6</sup>			
MISSILE, LAUNCH	50000.		70000.	8x10 <sup>6</sup>			

ENVIRONMENTAL FACTORS											
NON-OPERATING				OPERATING							
G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>		
MIL-STD 1.0	51.	51.	321.	690.	726.	690.	1071.	1310	8333	HI-REL	

QUALITY FACTORS											
NON-OPERATING				OPERATING							
MIL-STD	HI-REL	LOWER GRADE	MIL-STD	HI-REL							

PART CATEGORY: RESISTOR

DESCRIPTION: SEMIPRECISION, WIREWOUND POTENTIOMETER,  
MIL-R-19, Style RA and MIL-R-39002, Style RK

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			RANGE LOW	RANGE HIGH
			BEST ESTIMATE	90% CONFIDENCE			
NON-OPERATING GROUND, FIXED MIL-STD HI-REL	*	*	<8.4* N/A	19.4	-	-	-

ENVIRONMENT	FAILURE RATE IN FITS					
	MIL-STD			HI-REL		
	RANGE			RANGE		
OPERATING	LOW	BEST EST	HIGH	LOW	BEST EST	HIGH
GROUND, BENIGN	150.	260.	4600			
SPACE FLIGHT	-	**	-			
GROUND, FIXED	1100.	2300.	45000			
AIRBORNE, INHAB	3000.	6400.	135000			
NAVAL, SHELTERED	3900.	8600.	197000			
GROUND, MOBILE	4000.	8500.	180000			
NAVAL, UNSHEL.		**				
AIRBORNE, UNINHAB		**				
MISSILE, LAUNCH		**				

NON-OPERATING	ENVIRONMENTAL FACTORS									
	OPERATING									
G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>	
MIL-STD	1.0	31.	**	274.	762.1024.1012.	**	**	**	**	**
HI-REL										

QUALITY FACTORS											
NON-OPERATING						OPERATING					
MIL-STD	HI-REL	LOWER GRADE				MIL-STD				HI-REL	

\*See Resistor, Precision WW Potentiometer, MIL-R-12934, Style RR  
\*\*Not normally used in these environments.

PART CATEGORY: RESISTOR

DESCRIPTION: WIREWOUND (POWER) POTENTIOMETER, MIL-R-22, style RP

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
NON-OPERATING GROUND, FIXED MIL-STD HI-REL	*	*	<8.4*	19.4 N/A	-	-

ENVIRONMENT	FAILURE RATE IN FITS						
	MIL-STD			HI-REL			
	RANGE	LOW	BEST EST	HIGH	LOW	BEST EST	HIGH
<u>OPERATING</u>							
GROUND, BENIGN	190.	290.	7900				
SPACE FLIGHT		**					
GROUND, FIXED	1400.	2300.	59000				
AIRBORNE, INHAB	3500.	6000.	180000				
NAVAL, SHELTERED	4700.	7500.	216000				
GROUND, MOBILE	5200.	8100.	241000				
NAVAL, UNSHEL.		**					
AIRBORNE, UNINHAB		**					
MISSILE, LAUNCH		**					

NON-OPERATING	ENVIRONMENTAL FACTORS									
	OPERATING					NON-OPERATING				
G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>	
MIL-STD 1.0	35.	**	274.	714.	893.	964.	**	**	**	**
HI-REL										

QUALITY FACTORS									
NON-OPERATING					OPERATING				
MIL-STD	HI-REL	LOWER GRADE				MIL-STD	HI-REL		

\*See Resistor, Precision Wirewound Potentiometer, MIL-R-12934.  
\*\*Not normally used in these environments.

PART CATEGORY: RESISTOR

DESCRIPTION: VARIABLE (NON-WIREWOUND TRIMMER) MIL-R-39035, Style RTR

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
<u>NON-OPERATING</u> GROUND, FIXED MIL-STD HI-REL	*	*	N/A 3.71	9.87	-	43.5

ENVIRONMENT	FAILURE RATE IN FITS					
	MIL-STD			HI-REL		
	RANGE		RANGE			
	LOW	BEST EST.	HIGH	LOW	BEST EST.	HIGH
<u>OPERATING</u> GROUND, BENIGN SPACE FLIGHT GROUND, FIXED AIRBORNE, INHAB NAVAL, SHELTERED GROUND, MOBILE NAVAL, UNSHEL. AIRBORNE, UNINHAB MISSILE, LAUNCH	550.	650	3650			
		**				
	1750	2300	13000			
	3750	4750	29000			
	5000	6500	38500			
	6000	8000	48500			
	8500	11500	50000			
	10000	13500	1x10 <sup>5</sup>			
	40500	50000	3x10 <sup>5</sup>			

ENVIRONMENTAL FACTORS										
NON-OPERATING					OPERATING					
<u>G<sub>F</sub></u>	<u>G<sub>B</sub></u>	<u>S<sub>F</sub></u>	<u>G<sub>F</sub></u>	<u>A<sub>I</sub></u>	<u>N<sub>S</sub></u>	<u>G<sub>M</sub></u>	<u>N<sub>U</sub></u>	<u>A<sub>U</sub></u>	<u>M<sub>L</sub></u>	
MIL-STD										
HI-REL	1.0	175	**	620	1280	1752	2156	3100	3639	13477

QUALITY FACTORS									
NON-OPERATING					OPERATING				
<u>MIL-STD</u>	<u>HI-REL</u>	<u>L</u>	<u>M</u>	<u>P</u>	<u>R</u>	<u>S</u>	<u>L</u>	<u>M</u>	<u>P</u>

\*See Resistor, Variable, Wirewound, MIL-R-39015, Style RTR

\*\*Not normally used in these environments.

PART CATEGORY: RESISTOR

DESCRIPTION: VARIABLE (NON-WIREWOUND TRIMMERS), MIL-R-22097,  
Style RJ

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			RANGE LOW	RANGE HIGH
			BEST ESTIMATE	90% CONFIDENCE			
NON-OPERATING GROUND, FIXED MIL-STD HI-REL	*	*	<8.4*	N/A	19.4	-	-

ENVIRONMENT	FAILURE RATE IN FITS					
	MIL-STD			HI-REL		
	RANGE		RANGE			
LOW	BEST EST	HIGH	LOW	BEST EST	HIGH	
OPERATING						
GROUND, BENIGN	1100	1300.	7300			
SPACE FLIGHT		**				
GROUND, FIXED	3500	4600.	26000			
AIRBORNE, INHAB	7500	9500.	58000			
NAVAL, SHELTERED	10000	13000.	77000			
GROUND, MOBILE	12000	16000.	97000			
NAVAL, UNSHEL.	17000	23000.	1x10 <sup>5</sup>			
AIRBORNE, UNINHAB	20000	27000.	2x10 <sup>5</sup>			
MISSILE, LAUNCH	81000	100000.	5x10 <sup>5</sup>			

NON-OPERATING	ENVIRONMENTAL FACTORS									
	OPERATING									
	G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>
MIL-STD	1.0	155	**	548	1131	1548	1905	2738	3214	11905
HI-REL										

QUALITY FACTORS									
NON-OPERATING					OPERATING				
MIL-STD	HI-REL	LOWER GRADE	MIL-STD	HI-REL					

\*See Resistor, Precision WW, Potentiometer, MIL-R-12934, Style RR  
\*\*Not normally used in these environments.

PART CATEGORY: RESISTOR

DESCRIPTION: COMPOSITION (LOW PRECISION) POTENTIOMETER,  
MIL-R-94, style RV

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
NON-OPERATING GROUND, FIXED MIL-STD HI-REL	*	*	<8.4* N/A	19.4	-	-

ENVIRONMENT	LOW	FAILURE RATE IN FITS			HIGH
		MIL-STD		HI-REL	
		RANGE	BEST EST	HIGH	
OPERATING					
GROUND, BENIGN	200	270.	1800		
SPACE FLIGHT		**			
GROUND, FIXED	2200	3700.	28000		
AIRBORNE, INHAB	12000	20000.	2x10 <sup>5</sup>		
NAVAL, SHELTERED	13000	22000.	94000		
GROUND, MOBILE	12000	20000.	2x10 <sup>5</sup>		
NAVAL, UNSHEL.	18000	34000.	3x10 <sup>5</sup>		
AIRBORNE, UNINHAB	18000	34000.	3x10 <sup>5</sup>		
MISSILE, LAUNCH	25000	40000.	3x10 <sup>5</sup>		

ENVIRONMENTAL FACTORS											
NON-OPERATING				OPERATING							
G <sub>F</sub>	G <sub>B</sub>	S <sub>T</sub>	G <sub>F</sub>	I <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>		
MIL-STD 1.0	32	**	440	2381	2619	2381	4048	4048	4762		
HI-REL											

QUALITY FACTORS											
NON-OPERATING						OPERATING					
MIL-STD	HI-REL	LOWER GRADE	MIL-STD	HI-REL							

\*See Resistor, Precision WW Potentiometer, MIL-R-12934, Style RR  
\*\*Not normally used in these environments.

PART CATEGORY: RESISTOR

DESCRIPTION: TIN OXIDE

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS		
			BEST ESTIMATE	90% CONFIDENCE	RANGE
			LOW	HIGH	
<u>NON-OPERATING</u>					
GROUND, FIXED	0	465.5	(<2.1)	5.0	

ENVIRONMENT	FAILURE RATE IN FITS					
	MIL-STD			HI-REL		
	RANGE		RANGE			
	LOW	BEST EST.	HIGH	LOW	BEST EST.	HIGH
<u>OPERATING</u>						
GROUND, BENIGN						
SPACE FLIGHT						
GROUND, FIXED						
AIRBORNE, INHAB						
NAVAL, SHELTERED						
GROUND, MOBILE						
NAVAL, UNSHEL.						
AIRBORNE, UNINHAB						
MISSILE, LAUNCH						

NON-OPERATING	ENVIRONMENTAL FACTORS									
	OPERATING									
G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>	

NON-OPERATING	QUALITY FACTORS									
	OPERATING									

PART CATEGORY: RESISTOR

DESCRIPTION: NETWORK

ENVIRONMENT	FAILURES	PART HOURS ( $10^6$ )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
<u>NON-OPERATING</u> GROUND, FIXED MIL-STD HI-REL	-0	-1.1	-(<909.1)	-2100.	-	-

ENVIRONMENT	FAILURE RATE IN FITS					
	MIL-STD			HI-REL		
	RANGE			RANGE		
	LOW	BEST EST.	HIGH	LOW	BEST EST.	HIGH
<u>OPERATING</u> GROUND, BENIGN SPACE FLIGHT GROUND, FIXED AIRBORNE, INHAB NAVAL, SHELTERED GROUND, MOBILE NAVAL, UNSHEL. AIRBORNE, UNINHAB MISSILE, LAUNCH						

NON-OPERATING	ENVIRONMENTAL FACTORS									
	OPERATING									
	G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>

NON-OPERATING	QUALITY FACTORS									
	OPERATING									

**PART CATEGORY: CAPACITOR**

**DESCRIPTION: PAPER & PLASTIC FILM - MIL-C-39022, Style CHR;  
MIL-C-14157, Style CPV; & MIL-C 19978, Style CQR.**

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS		
			BEST ESTIMATE	90% CONFIDENCE	RANGE
NON-OPERATING					
GROUND, FIXED MIL-STD HI-REL	2	1797.	1.11	2.96	- 41.7

ENVIRONMENT	FAILURE RATE IN FITS					
	MIL-STD			HI-REL		
	RANGE			RANGE		
	LOW	BEST EST.	HIGH	LOW	BEST EST.	HIGH
<b>OPERATING</b>						
GROUND, BENIGN				.07	.2	7.
SPACE FLIGHT				.07	.2	7.
GROUND, FIXED				.16	.6	15.
AIRBORNE, INHAB				.36	1.2	34.
NAVAL, SHELTERED				.40	1.6	40.
GROUND, MOBILE				.36	1.2	34.
NAVAL, UNSHEL.				1.8	9.0	210.
AIRBORNE, UNINHAB				3.0	12.	340.
MISSILE, LAUNCH				1.8	6.	170.

ENVIRONMENTAL FACTORS										
NON-OPERATING					OPERATING					
G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>	
MIL-STD										
HI-REL	1.0	.18	.18	.54	1.1	1.4	1.1	8.1	11.	5.4

QUALITY FACTORS										
NON-OPERATING					OPERATING					
MIL-STD	HI-REL		L	M	P	R	S			
1.0	.27		1.5	1.0	.3	.1	.01			

PART CATEGORY: CAPACITOR

DESCRIPTION: PAPER & PLASTIC FILM - MIL-C-19978, Style CQ

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
NON-OPERATING GROUND, FIXED MIL-STD HI-REL	.8	1950.	4.1 N/A	6.67	-	6.08

ENVIRONMENT	FAILURE RATE IN FITS					
	MIL-STD			HI-REL		
	RANGE		RANGE			
OPERATING	LOW	BEST EST	HIGH	LOW	BEST EST	HIGH
GROUND, BENIGN	.7	2.	70.		N/A	
SPACE FLIGHT	.7	2.	70.			
GROUND, FIXED	1.6	6.	150.			
AIRBORNE, INHAB	3.6	12.	340.			
NAVAL, SHELTERED	4.0	16.	400.			
GROUND, MOBILE	3.6	12.	340.			
NAVAL, UNSHEL.	18.	90.	2100.			
AIRBORNE, UNINHAB	30.	120.	3400.			
MISSILE, LAUNCH	18.	60.	1700.			

ENVIRONMENTAL FACTORS											
NON-OPERATING				OPERATING							
G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>		
MIL-STD	1.0	.5	.5	1.5	2.9	3.9	2.9	22.	29.	15.	
HI-REL											

QUALITY FACTORS											
NON-OPERATING						OPERATING					
MIL-STD	HI-REL					L	M	P	R	S	
1.0	.27										

PART CATEGORY: CAPACITOR

DESCRIPTION: MICA, MIL-C-39001, Style CMR

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
NON-OPERATING					LOW	HIGH
GROUND, FIXED MIL-STD HI-REL	2	3271.	.61*	1.63	-	434.

ENVIRONMENT	FAILURE RATE IN FITS					
	MIL-STD			HI-REL		
	RANGE		RANGE		LOW	BEST EST.
OPERATING	LOW	BEST EST.	HIGH	LOW	BEST EST.	HIGH
GROUND, BENIGN				.1	.3	2.2
SPACE FLIGHT				.1	.3	2.2
GROUND, FIXED				.8	3.2	13.
AIRBORNE, INHAB				1.8	6.0	37.
NAVAL, SHELTERED				1.8	7.8	29.
GROUND, MOBILE				1.8	6.0	37.
NAVAL, UNSHEL.				11.	34.	180.
AIRBORNE, UNINHAB				14.	48.	260.
MISSILE, LAUNCH				6.	30.	120.

NON-OPERATING	ENVIRONMENTAL FACTORS								
	OPERATING								
<u>G<sub>F</sub></u>	<u>G<sub>B</sub></u>	<u>S<sub>F</sub></u>	<u>G<sub>F</sub></u>	<u>A<sub>I</sub></u>	<u>N<sub>S</sub></u>	<u>G<sub>M</sub></u>	<u>N<sub>U</sub></u>	<u>A<sub>U</sub></u>	<u>M<sub>L</sub></u>
MIL-STD									
HI-REL	1.0	.5	.5	5.2	9.8	13.	98.	56.	79.
									49.

QUALITY FACTORS									
NON-OPERATING					OPERATING				
MIL-STD	HI-REL	<u>L</u>	<u>M</u>	<u>P</u>	<u>R</u>	<u>S</u>			
1.0	1.0	-	1.0	.3	.1	.03			

\*Combination MIL-STD & HI-REL Data.

PART CATEGORY: CAPACITOR

DESCRIPTION: MICA, MIL-C-5, Style CM

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
NON-OPERATING GROUND, FIXED MIL-STD HI-REL	*	*	.61 N/A	1.63	-	434.

ENVIRONMENT	FAILURE RATE IN FITS						
	MIL-STD			HI-REL			
	RANGE	LOW	BEST EST	HIGH	LOW	BEST EST	HIGH
<u>OPERATING</u>							
GROUND, BENIGN	1.	3.	22.		N/A		
SPACE FLIGHT	1.	3.	22.				
GROUND, FIXED	8.	32.	130.				
AIRBORNE, INHAB	18.	60.	370.				
NAVAL, SHELTERED	18.	78.	290.				
GROUND, MOBILE	18.	60.	370.				
NAVAL, UNSHEL.	110.	340.	1800.				
AIRBORNE, UNINHAB	140.	480.	2600.				
MISSILE, LAUNCH	60.	300.	1200.				

ENVIRONMENTAL FACTORS										
NON-OPERATING			OPERATING							
G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>	
MIL-STD	1.0	4.9	4.9	52.	98.	128.	98.	557.	787.	492.
HI-REL										

QUALITY FACTORS										
NON-OPERATING					OPERATING					
MIL-STD	HI-REL	L	M	P	R	S				
1.0	1.0									

\*See Capacitor, Mica, MIL-C-39001, Style CMR.

PART CATEGORY: CAPACITOR

DESCRIPTION: MICA, MIL-C-10950, Style CB

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
NON-OPERATING GROUND, FIXED MIL-STD HI-REL	*	*	.61 N/A	1.63	-	434.

ENVIRONMENT	FAILURE RATE IN FITS					
	MIL-STD			HI-REL		
	RANGE			RANGE		
OPERATING	LOW	BEST EST	HIGH	LOW	BEST EST	HIGH
GROUND, BENIGN	41.	120.	670.		N/A	
SPACE FLIGHT	41.	120.	670.			
GROUND, FIXED	200.	580.	3300.			
AIRBORNE, INHAB	320.	930.	5100.			
NAVAL, SHELTERED	350.	990.	5600.			
GROUND, MOBILE	320.	930.	5100.			
NAVAL, UNSHEL.	1300.	3700.	21000.			
AIRBORNE, UNINHAB	1600.	4800.	26000.			
MISSILE, LAUNCH	1600.	4700.	26000.			

NON-OPERATING	ENVIRONMENTAL FACTORS									
	OPERATING									
	G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>
MIL-STD	1.0	197	197	951	1525	1623	1525	6066	7869	7705
HI-REL										

QUALITY FACTORS									
NON-OPERATING					OPERATING				
MIL-STD	HI-REL	L	M	P	R	S			

\*See Capacitor, MICA-MIL-C-39001, Style CMR

PART CATEGORY: CAPACITOR

DESCRIPTION: GLASS, MIL-C-23269, Style CYR

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
				LOW		HIGH
<u>NON-OPERATING</u>						
GROUND, FIXED MIL-STD HI-REL	0	1597.	N/A <0.63	1.45	-	-

ENVIRONMENT	FAILURE RATE IN FITS					
	MIL-STD			HI-REL		
	RANGE			RANGE		
	LOW	BEST EST.	HIGH	LOW	BEST EST.	HIGH
<u>OPERATING</u>						
GROUND, BENIGN				.6	1.3	10.
SPACE FLIGHT				.6	1.3	10.
GROUND, FIXED				5.6	11.	96.
AIRBORNE, INHAB				10.	21.	170.
NAVAL, SHELTERED				13.	25.	220.
GROUND, MOBILE				10.	21.	170.
NAVAL, UNSHEL.				55.	110.	920.
AIRBORNE, UNINHAB				84.	160.	1400.
MISSILE, LAUNCH				33.	110.	570.

ENVIRONMENTAL FACTORS										
NON-OPERATING			OPERATING							
G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>	
MIL-STD										
HI-REL	1.0	21.	21.	17.	33.	40.	33.	175.	254.	175.

QUALITY FACTORS										
NON-OPERATING					OPERATING					
MIL-STD	HI-REL	L	H	P	R	S				

PART CATEGORY: CAPACITOR

DESCRIPTION: CERAMIC, MIL-C-20, Style CCR  
MIL-C-39014, Style CKR

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
NON-OPERATING					LOW	HIGH
GROUND, FIXED MIL-STD HI-REL	2	6163.	N/A 0.32	0.86	.27	.64

ENVIRONMENT	FAILURE RATE IN FITS					
	MIL-STD			HI-REL		
	RANGE		RANGE			
	LOW	BEST EST.	HIGH	LOW	BEST EST.	HIGH
<u>OPERATING</u>						
GROUND, BENIGN				1.9	10.	71.
SPACE FLIGHT				1.9	10.	71.
GROUND, FIXED				4.	22.	150.
AIRBORNE, INHAB				8.	44.	300.
NAVAL, SHELTERED				8.	44.	300.
GROUND, MOBILE				8.	44.	300.
NAVAL, UNSHEL.				18.	96.	650.
AIRBORNE, UNINHAB				20.	110.	760.
MISSILE, LAUNCH				30.	170.	1100.

ENVIRONMENTAL FACTORS										
NON-OPERATING			OPERATING							
	G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>
MIL-STD										
HI-REL	1.0	31.	31.	69.	138.	138.	138.	300.	344.	531.

QUALITY FACTORS										
NON-OPERATING				OPERATING						
MIL-STD	HI-REL			L	M	P	R	S		
1.0	.15			1.5	1.0	.3	.1	.01		

PART CATEGORY: CAPACITOR

DESCRIPTION: CERAMIC, MIL-C-20, Style CC, MIL-C-11015, Style CK

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
NON-OPERATING GROUND, FIXED MIL-STD HI-REL	3	1400	2.14 N/A	4.76	-	4.12

ENVIRONMENT	FAILURE RATE IN FITS						
	MIL-STD			HI-REL			
	RANGE	LOW	BEST EST	HIGH	LOW	BEST EST	HIGH
<u>OPERATING</u>							
GROUND, BENIGN	19.	100.	710.			N/A	
SPACE FLIGHT	19.	100.	710.				
GROUND, FIXED	40.	220.	1500.				
AIRBORNE, INHAB	80.	440.	3000.				
NAVAL, SHELTERED	80.	440.	3000.				
GROUND, MOBILE	80.	440.	3000.				
NAVAL, UNSHEL.	180.	960.	6500.				
AIRBORNE, UNINHAB	200.	1100.	7600.				
MISSILE, LAUNCH	300.	1700.	11000.				

NON-OPERATING	ENVIRONMENTAL FACTORS									
	OPERATING					NON-OPERATING				
	G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>
MIL-STD	1.0	47.	47.	103.	206.	206.	206.	449.	514.	794.
HI-REL										

QUALITY FACTORS									
NON-OPERATING					OPERATING				
MIL-STD	HI-REL	L	M	P	R	S			
1.0	.15								

PART CATEGORY: CAPACITOR

DESCRIPTION: TANTALUM ELECTROLYTIC (SOLID), MIL-C-39003, Style CSR

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS		
			BEST ESTIMATE	90% CONFIDENCE	RANGE LOW      HIGH
<u>NON-OPERATING</u> GROUND, FIXED MIL-STD HI-REL	1	7687	N/A 0.13	0.51	-      .49

ENVIRONMENT	FAILURE RATE IN FITS						
	MIL-STD			HI-REL			
	RANGE		RANGE		LOW	BEST EST.	HIGH
<u>OPERATING</u> GROUND, BENIGN					3.8	11.	62.
SPACE FLIGHT					3.8	11.	62.
GROUND, FIXED					9.0	26.	150.
AIRBORNE, INHAB					18.	52.	300.
NAVAL, SHELTERED					20.	56.	330.
GROUND, MOBILE					18.	52.	300.
NAVAL, UNSHEL.					59.	170.	900.
AIRBORNE, UNINHAB					90.	260.	1500.
MISSILE, LAUNCH					96.	260.	1600.

NON-OPERATING	ENVIRONMENTAL FACTORS														
	OPERATING					G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>
MIL-STD HI-REL	1.0	85.	85.	200.	400.	431.	400.	1308.	2000.	2000.					

QUALITY FACTORS									
NON-OPERATING					OPERATING				
MIL-STD	HI-REL	L	M	P	R	S			

PART CATEGORY: CAPACITOR

DESCRIPTION: TANTALUM ELECTROLYTIC (NON-SOLID), MIL-C-39006,  
Style CLR

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
<u>NON-OPERATING</u> GROUND, FIXED MIL-STD HI-REL	4	446.	N/A 9.0	17.9	-	9.3

ENVIRONMENT	FAILURE RATE IN FITS					
	MIL-STD			HI-REL		
	RANGE			RANGE		
	LOW	BEST EST.	HIGH	LOW	BEST EST.	HIGH
<u>OPERATING</u> GROUND, BENIGN SPACE FLIGHT GROUND, FIXED AIRBORNE, INHAB NAVAL, SHIELDED GROUND, MC E NAVAL, UNSH AIRBORNE, UNINHAB MISSILE, LAUNCH				5.0 5.0 11. 37. 37. 37. 120. 150. 180.	15. 15. 34. 110. 110. 110. 340. 440. 540.	82. 82. 190. 600. 600. 600. 1900. 2500. 3000.

NON-OPERATING	ENVIRONMENTAL FACTORS									
	OPERATING									
G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>	
MIL-STD HI-REL	1.0	1.7	1.7	3.8	12.	12.	12.	38.	49.	60.

QUALITY FACTORS									
NON-OPERATING					OPERATING				
MIL-STD	HI-REL	L	M	P	R	S			
1.0	.7	1.5	1.0	.3	.1	.01			

PART CATEGORY: CAPACITOR

DESCRIPTION: TANTALUM ELECTROLYTIC (NON-SOLID), MIL-C-3965,  
Style CL

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
NON-OPERATING GROUND, FIXED MIL-STD HI-REL	4	319.	12.5 N/A	25.1	-	2500.

ENVIRONMENT	FAILURE RATE IN FITS						
	MIL-STD			HI-REL			
	RANGE	LOW	BEST EST	HIGH	LOW	BEST EST	HIGH
<b>OPERATING</b>							
GROUND, BENIGN	50.	150.	820.		N/A		
SPACE FLIGHT	50.	150.	820.				
GROUND, FIXED	110.	340.	1900.				
AIRBORNE, INHAB	370.	1100.	6000.				
NAVAL, SHELTERED	370.	1100.	6000.				
GROUND, MOBILE	370.	1100.	6000.				
NAVAL, UNSHEL.	120.	3400.	19000.				
AIRBORNE, UNINHAB	150.	4400.	25000.				
MISSILE, LAUNCH	180.	5400.	30000.				

NON-OPERATING	ENVIRONMENTAL FACTORS									
	OPERATING					NON-OPERATING				
	G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>
MIL-STD	1.0	12.	12.	27.	88.	88.	88.	272.	352.	432.
HI-REL										

QUALITY FACTORS									
NON-OPERATING					OPERATING				
MIL-STD	HI-REL		L	M	P	R	S		
1.0	.7								

PART CATEGORY: CAPACITOR

DESCRIPTION: ALUMINUM OXIDE, MIL-C-39018, Style CU

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
NON-OPERATING GROUND, FIXED MIL-STD HI-REL	0	155.	<6.46 N/A	14.9	-	-

ENVIRONMENT	FAILURE RATE IN FITS						
	MIL-STD			HI-REL			
	RANGE	LOW	BEST EST	HIGH	LOW	BEST EST	HIGH
OPERATING GROUND, BENIGN	36.	73.	300.		N/A		
SPACE FLIGHT	36.	73.	300.				
GROUND, FIXED	110.	230.	1000.				
AIRBORNE, INHAB	830.	1600.	7200.				
NAVAL, SHELTERED	940.	1900.	8300.				
GROUND, MOBILE	830.	1600.	7200.				
NAVAL, UNSHEL.	2600.	5300.	24000.				
AIRBORNE, UNINHAB	3600.	6900.	33000.				
MISSILE, LAUNCH	2800.	5400.	24000.				

NON-OPERATING	ENVIRONMENTAL FACTORS									
	OPERATING									
G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>	
MIL-STD	1.0	11.	11.	36.	248.	294.	248.	820.	1068.	836.
HI-REL										

QUALITY FACTORS											
NON-OPERATING						OPERATING					
MIL-STD	HI-REL	L	M	P	R	S					

PART CATEGORY: CAPACITOR

DESCRIPTION: ALUMINUM DRY ELECTROLYTIC, MIL-C-62, Style CE

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS		
			BEST ESTIMATE	90% CONFIDENCE	RANGE
			LOW	HIGH	
NON-OPERATING GROUND, FIXED MIL-STD HI-REL			TBD		

ENVIRONMENT	FAILURE RATE IN FITS					
	MIL-STD			HI-REL		
	RANGE		RANGE		LOW	BEST EST
OPERATING	LOW	BEST EST	HIGH	LOW		
GROUND, BENIGN	60.	110.	420.		N/A	
SPACE FLIGHT	60.	110.	420.			
GROUND, FIXED	240.	410.	1600.			
AIRBORNE, INHAB	1700.	3000.	12000.			
NAVAL, SHELTERED	2200.	3800.	15000.			
GROUND, MOBILE	1700.	3000.	12000.			
NAVAL, UNSHEL.	8100.	14000.	56000.			
AIRBORNE, UNINHAB	9100.	16000.	63000.			
MISSILE, LAUNCH	5800.	10000.	40000.			

NON-OPERATING	ENVIRONMENTAL FACTORS									
	OPERATING									
G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>	
MIL-STD										
HI-REL										

QUALITY FACTORS									
NON-OPERATING					OPERATING				
MIL-STD	HI-REL	L	M	P	R	S			

PART CATEGORY: CAPACITOR

DESCRIPTION: VARIABLE CERAMIC, MIL-C-81, Style CV

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
NON-OPERATING GROUND, FIXED MIL-STD HI-REL		TBD N/A		LOW	HIGH	

ENVIRONMENT	FAILURE RATE IN FITS					
	MIL-STD			HI-REL		
	RANGE			RANGE		
OPERATING	LOW	BEST EST	HIGH	LOW	BEST EST	HIGH
GROUND, BENIGN	11.	200.	1600		N/A	
SPACE FLIGHT	11.	200.	1600			
GROUND, FIXED	51.	1100.	8600			
AIRBORNE, INHAB	110.	2400.	19000			
NAVAL, SHELTERED	120.	2700.	11000			
GROUND, MOBILE	110.	2400.	19000			
NAVAL, UNSHEL.	570.	12000.	97000			
AIRBORNE, UNINHAB	1000.	22000.	170000			
MISSILE, LAUNCH	980.	21000.	165000			

NON-OPERATING	ENVIRONMENTAL FACTORS									
	OPERATING									
	G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>
MIL-STD HI-REL										

QUALITY FACTORS									
NON-OPERATING					OPERATING				
MIL-STD	HI-REL	L	M	P	R	S			

## PART CATEGORY: CAPACITOR

DESCRIPTION: VARIABLE, PISTON TYPE, MIL-C-14409, Style PC

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
NON-OPERATING GROUND, FIXED MIL-STD HI-REL	0	154.8	<6.46 N/A	14.9	-	-

ENVIRONMENT	FAILURE RATE IN FITS					
	MIL-STD			HI-REL		
	RANGE			RANGE		
OPERATING	LOW	BEST EST	HIGH	LOW	BEST EST	HIGH
GROUND, BENIGN	4.4	16.	120.			
SPACE FLIGHT	4.4	16.	120.			
GROUND, FIXED	24.	110.	670.			
AIRBORNE, INHAB	90.	410.	2700.			
NAVAL, SHELTERED	110.	470.	3000.			
GROUND, MOBILE	90.	410.	2700.			
NAVAL, UNSHEL.	820.	3800.	22000.			
AIRBORNE, UNINHAB	870.	5300.	24000.			
MISSILE, LAUNCH	710.	4900.	20000.			

NON-OPERATING	ENVIRONMENTAL FACTORS									
	OPERATING									
	G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>
MIL-STD	1.0	2.5	2.5	17.	63.	73.	63.	588.	820.	759.
HI-REL										

QUALITY FACTORS									
NON-OPERATING					OPERATING				
MIL-STD	HI-REL	L	M	P	R	S			

PART CATEGORY: CAPACITOR

DESCRIPTION: TITANIUM

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
LOW	HIGH					
<u>NON-OPERATING</u> GROUND, FIXED	0	51	(<19.6)	45.3	-	-

ENVIRONMENT	FAILURE RATE IN FITS					
	MIL-STD			HI-REL		
	RANGE			RANGE		
	LOW	BEST EST.	HIGH	LOW	BEST EST.	HIGH
<u>OPERATING</u>						
GROUND, BENIGN						
SPACE FLIGHT						
GROUND, FIXED						
AIRBORNE, INHAB						
NAVAL, SHELTERED						
GROUND, MOBILE						
NAVAL, UNSHEL.						
AIRBORNE, UNINHAB						
MISSILE, LAUNCH						

ENVIRONMENTAL FACTORS									
NON-OPERATING					OPERATING				
G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>

QUALITY FACTORS									
NON-OPERATING					OPERATING				

PART CATEGORY: CAPACITOR

DESCRIPTION: TUBULAR TEMP.

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS		
			BEST ESTIMATE	90% CONFIDENCE	RANGE
NON-OPERATING					
GROUND, FIXED	0	12.8	(<78.1)	180.	-

ENVIRONMENT	FAILURE RATE IN FITS					
	MIL-STD			HI-REL		
	RANGE			RANGE		
	LOW	BEST EST.	HIGH	LOW	BEST EST.	HIGH
OPERATING						
GROUND, BENIGN						
SPACE FLIGHT						
GROUND, FIXED						
AIRBORNE, INHAB						
NAVAL, SHELTERED						
GROUND, MOBILE						
NAVAL, UNSHEL.						
AIRBORNE, UNINHAB						
MISSILE, LAUNCH						

NON-OPERATING	ENVIRONMENTAL FACTORS								
	OPERATING								
G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>

QUALITY FACTORS									
NON-OPERATING					OPERATING				

PART CATEGORY: CAPACITOR

DESCRIPTION: DIFFERENTIAL, DUAL MODE

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
<u>NON-OPERATING</u>						
GROUND, FIXED	0	63.8	(<15.7)	36.2	-	-

ENVIRONMENT	FAILURE RATE IN FITS					
	MIL-STD			HI-REL		
	RANGE		RANGE			
	LOW	BEST EST.	HIGH	LOW	BEST EST.	HIGH
<u>OPERATING</u>						
GROUND, BENIGN						
SPACE FLIGHT						
GROUND, FIXED						
AIRBORNE, INHAB						
NAVAL, SHELTERED						
GROUND, MOBILE						
NAVAL, UNSHEL.						
AIRBORNE, UNINHAB						
MISSILE, LAUNCH						

NON-OPERATING	ENVIRONMENTAL FACTORS									
	OPERATING									
G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>	

NON-OPERATING	QUALITY FACTORS									
	OPERATING									

**PART CATEGORY:** CAPACITOR

**DESCRIPTION:** METALIZED POLYCARBONATE

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS		
			BEST ESTIMATE	90% CONFIDENCE	RANGE
			LOW	HIGH	
<b>NON-OPERATING</b>					
GROUND, FIXED	2	108.4	18.5	49.1	- -

ENVIRONMENT	FAILURE RATE IN FITS					
	MIL-STD			HI-REL		
	RANGE			RANGE		
	LOW	BEST EST.	HIGH	LOW	BEST EST.	HIGH
<b>OPERATING</b>						
GROUND, BENIGN						
SPACE FLIGHT						
GROUND, FIXED						
AIRBORNE, INHAB						
NAVAL, SHELTERED						
GROUND, MOBILE						
NAVAL, UNSHEL.						
AIRBORNE, UNINHAB						
MISSILE, LAUNCH						

NON-OPERATING	ENVIRONMENTAL FACTORS									
	OPERATING									
G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>	

NON-OPERATING	QUALITY FACTORS									
	OPERATING									

PART CATEGORY: CAPACITOR

DESCRIPTION: VARIABLE, AIR

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS		
			BEST ESTIMATE	90% CONFIDENCE	RANGE
			LOW	HIGH	
<u>NON-OPERATING</u>					
GROUND, FIXED	2	55.8	35.8	95.3	- -

ENVIRONMENT	FAILURE RATE IN FITS					
	MIL-STD			HI-REL		
	RANGE		RANGE			
	LOW	BEST EST.	HIGH	LOW	BEST EST.	HIGH
<u>OPERATING</u>						
GROUND, BENIGN						
SPACE FLIGHT						
GROUND, FIXED						
AIRBORNE, INHAB						
NAVAL, SHELTERED						
GROUND, MOBILE						
NAVAL, UNSHEL.						
AIRBORNE, UNINHAB						
MISSILE, LAUNCH						

NON-OPERATING	ENVIRONMENTAL FACTORS									
	OPERATING									
G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>	

NON-OPERATING	QUALITY FACTORS									
	OPERATING									

PART CATEGORY: CAPACITOR

DESCRIPTION: NETWORK

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
NON-OPERATING					LOW	HIGH
GROUND, FIXED CLASS B	0	1.1	(<909.1)	2100.	-	-

ENVIRONMENT	FAILURE RATE IN FITS					
	MIL-STD			HI-REL		
	RANGE			RANGE		
	LOW	BEST EST.	HIGH	LOW	BEST EST.	HIGH
<b>OPERATING</b>						
GROUND, BENIGN						
SPACE FLIGHT						
GROUND, FIXED						
AIRBORNE, INHAB						
NAVAL, SHELTERED						
GROUND, MOBILE						
NAVAL, UNSHEL.						
AIRBORNE, UNINHAB						
MISSILE, LAUNCH						

ENVIRONMENTAL FACTORS									
NON-OPERATING					OPERATING				
G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>

QUALITY FACTORS									
NON-OPERATING					OPERATING				

PART CATEGORY: INDUCTIVE DEVICES

DESCRIPTION: TRANSFORMERS & INDUCTORS, MIL-T-39013 (ER) and  
MIL-T-27

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS		
			BEST ESTIMATE	90% CONFIDENCE	RANGE
LOW	HIGH				
NON-OPERATING					
GROUND, FIXED					
MIL-STD	9	649.	13.9	21.9	-
HI-REL	3	3309.	0.91	2.01	17.7 1.0

ENVIRONMENT	FAILURE RATE IN FITS					
	MIL-STD			HI-REL		
	LOW	BEST EST	HIGH	LOW	BEST EST	HIGH
<u>OPERATING</u>						
GROUND, BENIGN		2.5			1.25	
SPACE FLIGHT		2.5			1.25	
GROUND, FIXED		6.6			3.3	
AIRBORNE, INHAB		18.			9.	
NAVAL, SHELTERED		20.			10.	
GROUND, MOBILE		11.			5.5	
NAVAL, UNSHEL.		27.			13.5	
AIRBORNE, UNINHAB		34.			17.	
MISSILE, LAUNCH		36.			18.	

NON-OPERATING	ENVIRONMENTAL FACTORS									
	OPERATING									
G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>	
MIL-STD	1.0	.18	.18	.47	1.3	1.4	.79	1.9	2.4	2.6
HI-REL	1.0	1.4	1.4	3.6	9.9	11.	6.0	15.	19.	20.

QUALITY FACTORS											
NON-OPERATING						OPERATING					
MIL-STD	HI-REL	LOWER GRADE	MIL-STD	HI-REL		MIL-STD	HI-REL		MIL-STD	HI-REL	
1.0	0.07		-	1.0			.5				

PART CATEGORY: INDUCTIVE DEVICES

DESCRIPTION: COILS, RADIO FREQUENCY, MIL-C-15305

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
NON-OPERATING GROUND, FIXED						
MIL-STD HI-REL	0	746.	< 1.34	3.10	-	-
	2	1806.	1.11	2.95	-	2.74

ENVIRONMENT	FAILURE RATE IN FITS					
	MIL-STD			HI-REL		
	LOW	BEST EST	HIGH	LOW	BEST EST	HIGH
OPERATING						
GROUND, BENIGN		9.6			4.8	
SPACE FLIGHT		9.6			4.8	
GROUND, FIXED		22.			11.	
AIRBORNE, INHAB		60.			30.	
NAVAL, SHELTERED		66.			33.	
GROUND, MOBILE		36.			18.	
NAVAL, UNSHEL.		84.			42.	
AIRBORNE, UNINHAB		110.			55.	
MISSILE, LAUNCH		120.			60.	

ENVIRONMENTAL FACTORS											
NON-OPERATING				OPERATING							
G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>		
MIL-STD	1.0	7.2	7.2	16.	45.	49.	27.	63.	82.	90.	
HI-REL	1.0	4.3	4.3	9.9	27.	30.	16.	38.	50.	54.	

QUALITY FACTORS											
NON-OPERATING				OPERATING							
MIL-STD	HI-REL	LOWER GRADE	MIL-STD	HI-REL							
1.0	.8	-	1.0	.5							

PART CATEGORY: INDUCTIVE DEVICES

DESCRIPTION: TRANSFORMERS, PULSE, LOW POWER, MIL-T-39026 (ER)  
and MIL-T-21038

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
NON-OPERATING GROUND, FIXED MIL-STD HI-REL	*	*	13.9 0.91	21.9 2.01	-	17.7 1.0

ENVIRONMENT	FAILURE RATE IN FITS					
	MIL-STD			HI-REL		
	RANGE			RANGE		
LOW	BEST EST	HIGH	LOW	BEST EST	HIGH	
OPERATING GROUND, BENIGN		1.2			.79	
SPACE FLIGHT		1.2			.79	
GROUND, FIXED		2.7			1.78	
AIRBORNE, INHAB		7.5			4.95	
NAVAL, SHELTERED		8.3			5.48	
GROUND, MOBILE		4.5			2.97	
NAVAL, UNINHAB.		11.			7.26	
AIRBORNE, UNINHAB		14.			9.24	
MISSILE, LAUNCH		15.			9.9	

NON-OPERATING	ENVIRONMENTAL FACTORS									
	OPERATING									
G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>	
MIL-STD 1.0	.09	.09	.9	.54	.60	.32	.79	1.0	1.1	
HI-REL 1.0	.87	.87	2.0	5.4	6.0	3.3	8.0	10.	11.	

QUALITY FACTORS											
NON-OPERATING						OPERATING					
MIL-STD	HI-REL	LOWER GRADE	MIL-STD	HI-REL		MIL-STD	HI-REL		MIL-STD	HI-REL	
1.0	.07	-	-	-		1.0	.66		-	-	

\*See Inductive Devices, Transformers & Inductors, MIL-T-27.

## PART CATEGORY: INDUCTIVE DEVICES

## DESCRIPTION: FILTERS &amp; CHOKES

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
<u>NON-OPERATING</u>						
GROUND, FIXED						
MIL-STD	1	104.	9.62	37.4	-	2645.
HI-REL	2	3615.	0.55	1.47	-	.57

ENVIRONMENT	FAILURE RATE IN FITS					
	MIL-STD			HI-REL		
	RANGE		RANGE			
	LOW	BEST EST.	HIGH	LOW	BEST EST.	HIGH
<u>OPERATING</u>						
GROUND, BENIGN		7.5			3.75	
SPACE FLIGHT		7.5			3.75	
GROUND, FIXED		21.			11.	
AIRBORNE, INHAB		56.			28.	
NAVAL, SHELTERED		64.			32.	
GROUND, MOBILE		34.			17.	
NAVAL, UNSHEL.		96.			48.	
AIRBORNE, UNINHAB		120.			60.	
MISSILE, LAUNCH		110.			55.	

NON-OPERATING	ENVIRONMENTAL FACTORS									
	OPERATING									
G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>	
MIL-STD	1.0	.78	.78	2.2	5.8	6.7	3.5	10.	12.	11.
HI-REL	1.0	6.1	6.8	20.	51.	58.	31.	87.	109.	100.

QUALITY FACTORS									
NON-OPERATING					OPERATING				
MIL-STD	HI-REL	L	M	P	R	S			
1.0	.06								

PART CATEGORY: INDUCTIVE DEVICES

DESCRIPTION: REACTORS

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
NON-OPERATING GROUND, FIXED MIL-STD HI-REL	0 1	13. 321.	<76.9 3.12	178. 12.1	- -	- 4.05

ENVIRONMENT	FAILURE RATE IN FITS						
	MIL-STD			HI-REL			
	RANGE		RANGE		LOW	BEST EST	HIGH
OPERATING GROUND, BENIGN							
SPACE FLIGHT							
GROUND, FIXED							
AIRBORNE, INHAB							
NAVAL, SHELTERED							
GROUND, MOBILE							
NAVAL, UNSHEL.							
AIRBORNE, UNINHAB							
MISSILE, LAUNCH							

NON-OPERATING	ENVIRONMENTAL FACTORS									
	OPERATING									
G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>	
MIL-STD										
HI-REL										

QUALITY FACTORS									
NON-OPERATING					OPERATING				
MIL-STD	HI-REL	LOWER GRADE	MIL-STD	HI-REL					

PART CATEGORY: CRYSTALS  
 DESCRIPTION: MIL-C-3098

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			RANGE	
			BEST ESTIMATE	90% CONFIDENCE	LOW	HIGH	
<u>NON-OPERATING</u>							
GROUND, FIXED	4	102.	39.3	78.6	-	-	
<u>OPERATING</u>							
SATELLITE							
GROUND			200.				
GROUND, MOBILE							
AIRBORNE							
MISSILE							
SHIPBOARD							
SUBMARINE							
HELICOPTER							

ENVIRONMENTAL FACTORS								
NON-OPERATING			OPERATING					
G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
1.0		5.1						

PART CATEGORY: PRINTED WIRING BOARD

DESCRIPTION:

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS		
			BEST ESTIMATE	90% CONFIDENCE	RANGE
			LOW	HIGH	
<u>NON-OPERATING</u>					
GROUND, FIXED	2	2977	.67	1.79	- 3.81

ENVIRONMENT	FAILURE RATE IN FITS					
	MIL-STD			HI-REL		
	RANGE			RANGE		
	LOW	BEST EST.	HIGH	LOW	BEST EST.	HIGH
<u>OPERATING</u>						
GROUND, BENIGN		1.5				
SPACE FLIGHT		1.5				
GROUND, FIXED		2.4				
AIRBORNE, INHAB		7.2				
NAVAL, SHELTERED		4.8				
GROUND, MOBILE		4.8				
NAVAL, UNSHEL.		12.				
AIRBORNE, UNINHAB		24.				
MISSILE, LAUNCH		24.				

NON-OPERATING	ENVIRONMENTAL FACTORS									
	OPERATING									
	G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>
	1.0	2.2	2.2	3.6	11.	7.2	7.2	18.	36.	36.

QUALITY FACTORS									
NON-OPERATING					OPERATING				
MIL-STD	HI-REL	L	M	P	R	S			

## PART CATEGORY: CONNECTIONS &amp; CONNECTORS

DESCRIPTION: PIN CONNECTOR

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			RANGE
			BEST ESTIMATE	90% CONFIDENCE	LOW	
<u>NON-OPERATING</u>						
GROUND, FIXED	1	82444.	0.012	0.47	-	2.90
<u>OPERATING</u>						
SATELLITE						
GROUND	0	1514.	<.6	1.5		
GROUND, MOBILE						
AIRBORNE						
MISSILE						
SHIPBOARD						
SUBMARINE						
HELICOPTER						

## ENVIRONMENTAL FACTORS

NON-OPERATING	OPERATING					
	G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M
	1.0		50			

PART CATEGORY: CONNECTIONS & CONNECTORS

DESCRIPTION: SOLDER CONNECTION

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			RANGE	
			BEST ESTIMATE	90% CONFIDENCE	LOW	HIGH	
<u>NON-OPERATING</u>							
GROUND, FIXED	0	25385.	<.028	.065	-	-	
<u>OPERATING</u>							
SATELLITE							
GROUND	634	162329	3.9	4.1			
GROUND, MOBILE							
AIRBORNE	135	6000	22.5	25.2			
MISSILE							
SHIPBOARD	14	1640	8.5	12.3			
SUBMARINE							
HELICOPTER							

ENVIRONMENTAL FACTORS									
NON-OPERATING		OPERATING							
G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H	
1.0		139.		804.		304.			

## PART CATEGORY: CONNECTIONS &amp; CONNECTORS

DESCRIPTION: WELD CONNECTIONS

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			RANGE	
			BEST ESTIMATE	90% CONFIDENCE	LOW	HIGH	
<u>NON-OPERATING</u>							
GROUND, FIXED	0	5580.	<0.18	0.41	-	-	
<u>OPERATING</u>							
SATELLITE							
GROUND	112	65750	1.7	1.9			
GROUND, MOBILE							
AIRBORNE	7	157.	44.6	75.1			
MISSILE							
SHIPBOARD							
SUBMARINE							
HELICOPTER							

NON-OPERA	VG	ENVIRONMENTAL FACTORS								
		OPERATING								
		G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
		1.0		9.4		248.				

PART CATEGORY: INSTRUMENTS, MISSILE FLIGHT

DESCRIPTION:

ENVIRONMENT	FAILURES	PART HOURS ( $10^6$ )	FAILURE RATE IN FITS			RANGE	
			BEST ESTIMATE	90% CONFIDENCE	LOW	HIGH	
<u>NON-OPERATING</u>							
GROUND, FIXED	25	264.	94.7	124.	-	-	
<u>OPERATING</u>							
SATELLITE	3	.001	3000000.	6670000			
GROUND							
GROUND, MOBILE	44	58.18	756.	924.			
AIRBORNE	169.	.943	179215.	198152.			
MISSILE							
SHIPBOARD							
SUBMARINE	12	.702	17094.	25392.			
HELICOPTER	119	.5	233000.	268368			

ENVIRONMENTAL FACTORS

NON-OPERATING

OPERATING

G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
1.0	31679.		8.0	1892.			181.	2513.

PART CATEGORY: FUSES

DESCRIPTION:

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
NON-OPERATING					LOW	HIGH
GROUND, FIXED	0	4.7	(<212.8)	491.	-	-

ENVIRONMENT	FAILURE RATE IN FITS						
	MIL-STD			HI-REL			
	RANGE			RANGE			
	LOW	BEST EST.	HIGH	LOW	BEST EST.	HIGH	
<b>OPERATING</b>							
GROUND, BENIGN							
SPACE FLIGHT							
GROUND, FIXED							
AIRBORNE, INHAB							
NAVAL, SHELTERED							
GROUND, MOBILE							
NAVAL, UNSHEL.							
AIRBORNE, UNINHAB							
MISSILE, LAUNCH							

NON-OPERATING	ENVIRONMENTAL FACTORS									
	OPERATING									
G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>	

QUALITY FACTORS									
NON-OPERATING					OPERATING				
MIL-STD	HI-REL	L	M	P	R	S			

PART CATEGORY: HEATERS

DESCRIPTION:

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS		
			BEST ESTIMATE	90% CONFIDENCE	RANGE
NON-OPERATING					
GROUND, FIXED	0	2.6	(4384.6)	888.	

ENVIRONMENT	FAILURE RATE IN FITS					
	MIL-STD			HI-REL		
	RANGE			RANGE		
	LOW	BEST EST.	HIGH	LOW	BEST EST.	HIGH
<u>OPERATING</u>						
GROUND, BENIGN						
SPACE FLIGHT						
GROUND, FIXED						
AIRBORNE, INHAB						
NAVAL, SHELTERED						
GROUND, MOBILE						
NAVAL, UNSHEL.						
AIRBORNE, UNINHAB						
MISSILE, LAUNCH						

ENVIRONMENTAL FACTORS									
NON-OPERATING		OPERATING							
G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>
			2.6						

QUALITY FACTORS									
NON-OPERATING					OPERATING				
MIL-STD	HI-REL	L	M	P	R	S			

PART CATEGORY: MAGNETIC CORE

DESCRIPTION:

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS		
			BEST ESTIMATE	90% CONFIDENCE	RANGE
NON-OPERATING					
GROUND, FIXED	0	35799.	(<.028)	.065	

ENVIRONMENT	FAILURE RATE IN FITS					
	MIL-STD			HI-REL		
	RANGE			RANGE		
	LOW	BEST EST.	HIGH	LOW	BEST EST.	HIGH
<u>OPERATING</u>						
GROUND, BENIGN						
SPACE FLIGHT						
GROUND, FIXED						
AIRBORNE, INHAB						
NAVAL, SHELTERED						
GROUND, MOBILE						
NAVAL, UNSHEL.						
AIRBORNE, UNINHAB						
MISSILE, LAUNCH						

NON-OPERATING	ENVIRONMENTAL FACTORS									
	OPERATING									
G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>	

QUALITY FACTORS										
NON-OPERATING					OPERATING					
MIL-STD	HI-REL					L	M	P	R	S

**PART CATEGORY: SOLAR CELLS**

**DESCRIPTION:**

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS		
			BEST ESTIMATE	90% CONFIDENCE	RANGE
			LOW	HIGH	
<b>NON-OPERATING</b>					
GROUND, FIXED	8	748.6	10.7	17.4	
FAILURE RATE IN FITS					
ENVIRONMENT	MIL-STD			HI-REL	
	RANGE		RANGE		
LOW	BEST EST.	HIGH	LOW	BEST EST.	HIGH
<b>OPERATING</b>					
GROUND, BENIGN					
SPACE FLIGHT					
GROUND, FIXED					
AIRBORNE, INHAB					
NAVAL, SHELTERED					
GROUND, MOBILE					
NAVAL, UNSHEL.					
AIRBORNE, UNINHAB					
MISSILE, LAUNCH					
ENVIRONMENTAL FACTORS					
<b>NON-OPERATING</b>	<b>OPERATING</b>				
<u>G<sub>F</sub></u>	<u>G<sub>B</sub></u>	<u>S<sub>F</sub></u>	<u>G<sub>F</sub></u>	<u>A<sub>I</sub></u>	<u>N<sub>S</sub></u>
					<u>G<sub>M</sub></u>
					<u>N<sub>U</sub></u>
					<u>A<sub>U</sub></u>
					<u>M<sub>L</sub></u>
QUALITY FACTORS					
<b>NON-OPERATING</b>	<b>OPERATING</b>				
<u>MIL-STD</u>	<u>HI-REL</u>		<u>L</u>	<u>M</u>	<u>P</u>
				<u>R</u>	<u>S</u>

PART CATEGORY: SENSOR

**DESCRIPTION:**      **TEMPERATURE**

ENVIRONMENT	FAIL-URES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS				
			BEST ESTIMATE	90% CONFIDENCE	RANGE		
			LOW	HIGH			
<b>NON-OPERATING</b>							
GROUND, FIXED	0	2.1	(<476.2)	1100.			
<b>OPERATING</b>							
SATELLITE							
GROUND	2	.829	2413.	6416.			
GROUND, MOBILE	34	1.548	21964.	27607.			
AIRBORNE	682	7.017	97193.	102130			
MISSILE							
SHIPBOARD							
SUBMARINE	2	.007	285714.	759878.			
HELICOPTER	74	.458	161572	188225.			

## **ENVIRONMENTAL FACTORS**

<u>NON-OPERATING</u>	<u>OPERATING</u>							
<u>G<sub>F</sub></u>	<u>S<sub>A</sub></u>	<u>G</u>	<u>G<sub>M</sub></u>	<u>A</u>	<u>M</u>	<u>S<sub>H</sub></u>	<u>S<sub>U</sub></u>	<u>H</u>
1.0		5.1	46	204			600.	339.

PART CATEGORY: LAMPS

DESCRIPTION:

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
NON-OPERATING					LOW	HIGH
GROUND, FIXED	2	52.9	37.9	101.		

ENVIRONMENT	FAILURE RATE IN FITS					
	MIL-STD			HI-REL		
	RANGE		RANGE			
	LOW	BEST EST.	HIGH	LOW	BEST EST.	HIGH
<u>OPERATING</u>						
GROUND, BENIGN						
SPACE FLIGHT						
GROUND, FIXED		200				
AIRBORNE, INHAB						
NAVAL, SHELTERED						
GROUND, MOBILE						
NAVAL, UNSHEL.						
AIRBORNE, UNINHAB						
MISSILE, LAUNCH						

ENVIRONMENTAL FACTORS											
NON-OPERATING				OPERATING							
G <sub>F</sub>	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>		
				5.3							

QUALITY FACTORS											
NON-OPERATING						OPERATING					
MIL-STD	HI-REL			L	M	P	R	S			

PART CATEGORY: ACCELEROMETERS

DESCRIPTION: GENERAL

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			RANGE	
			BEST ESTIMATE	90% CONFIDENCE	LOW		
<u>NON-OPERATING</u>							
GROUND, FIXED	4	135.	29.7	59.3	24.	1923.	
<u>OPERATING</u>							
SATELLITE	0	.112	<8929.	20620.			
GROUND	485	9.234	52523.	55708.			
GROUND, MOBILE	0	.037	<27027.	62418.			
AIRBORNE	2619	11.07	236585.	242615.			
MISSILE	-	-	-	-			
SHIPBOARD	-	-	-	-			
SUBMARINE	-	-	-	-			
HELICOPTER	-	-	-	-			

ENVIRONMENTAL FACTORS

NON-OPERATING	OPERATING								
	G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
	1.0	301.	1768.	910.	7966.	-	-	-	-

PART CATEGORY: GYROSCOPE

DESCRIPTION: RATE

ENVIRONMENT	FAILURES	PART HOURS ( $10^6$ )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
<u>NON-OPERATING</u>						
GROUND, FIXED	24.	181.	133.	174.	121.	524.
<u>OPERATING</u>						
SATELLITE	-	-	-	-		
GROUND	33	1.269	26005.	32834.		
GROUND, MOBILE	4	.012	333333.	666667.		
AIRBORNE	5413	14.56	371772.	378328.		
MISSILE	26	.048	541667.	703829.		
SHIPBOARD	-	-	-	-		
SUBMARINE	-	-	-	-		
HELICOPTER	65	.255	254902.	299356.		

NON-OPERATING	ENVIRONMENTAL FACTORS								
	OPERATING								
	G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
1.0		-	196	2506	2795	4073	-	-	1917

PART CATEGORY: RELAY

DESCRIPTION: GENERAL

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
					LOW	HIGH
<u>NON-OPERATING</u>						
GROUND, FIXED	4	469.7	8.5	17.0	-	637.
<u>OPERATING</u>						
SATELLITE	1	118.8	8.4	33.		
GROUND	13	78.26	166.	242.		
GROUND, MOBILE	-	-	-	-		
AIRBORNE	58	8.602	6743.	8017.		
MISSILE	-	-	-	-		
SHIPBOARD	17	22.55	754.	1048.		
SUBMARINE	55	43.03	1278.	1529.		
HELICOPTER	157	2.531	62031.	68849.		

ENVIRONMENTAL FACTORS									
NON-OPERATING			OPERATING						
G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H	
1.0	1.0	20.	-	793.	-	89.	150.	7298.	

PART CATEGOKY: RELAY

DESCRIPTION: ARMATURE

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			RANGE
			BEST ESTIMATE	90% CONFIDENCE	LOW	
<b>NON-OPERATING</b>						
GROUND, FIXED	*	*	8.5	17.0		637
<b>OPERATING</b>						
SATELLITE	-	-	-	-		
GROUND	13	55.71	233.	341.		
GROUND, MOBILE	1	.814	1229.	4780.		
AIRBORNE	4	2.05	1951.	3902.		
MISSILE	-	-	-	-		
SHIPBOARD	116	126.7	916.	1034.		
SUBMARINE	6953.	6750.	1030.	1046.		
HELICOPTER	-	-	-	-		

ENVIRONMENTAL FACTORS

NON-OPERATING	OPERATING							
G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
1.0	-	27.	145.	230.	-	108.	121.	

\* See Relay, General

PART CATEGORY: RELAY

DESCRIPTION: CRYSTAL CAN, LATCHING

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			RANGE	
			BEST ESTIMATE	90% CONFIDENCE		LOW	HIGH
<u>NON-OPERATING</u>							
GROUND, FIXED	*	*	8.5	17.0	-	-	637
<u>OPERATING</u>							
SATELLITE	-	-	-	-	-	-	
GROUND	1	.047	21277.	82788.	-	-	
GROUND, MOBILE	-	-	-	-	-	-	
AIRBORNE	-	-	-	-	-	-	
MISSILE	-	-	-	-	-	-	
SHIPBOARD	-	-	-	-	-	-	
SUBMARINE	-	-	-	-	-	-	
HELICOPTER	-	-	-	-	-	-	

ENVIRONMENTAL FACTORS

NON-OPERATING

OPERATING

G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
1.0	-	2503.	-	-	-	-	-	-

\* See Relay, General

PART CATEGORY: RELAY

DESCRIPTION: LATCHING, GENERAL

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			RANGE	
			BEST ESTIMATE	90% CONFIDENCE			
			LOW	HIGH			
<u>NON-OPERATING</u>							
GROUND, FIXED	*	*	8.5	17.0	-	637	
<u>OPERATING</u>							
SATELLITE	0	3.721	<269.	621.			
GROUND	1	1.756	569.	2216.			
GROUND, MOBILE	-	-	-	-			
AIRBORNE	-	-	-	-			
MISSILE	-	-	-	-			
SHIPBOARD	-	-	-	-			
SUBMARINE	601	1759.	342.	360.			
HELICOPTER	-	-	-	-			

NON-OPERATING	ENVIRONMENTAL FACTORS							
	OPERATING							
	G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>
	1.0	32	67	-	-	-	-	40

\* See Relay, General

PART CATEGORY: RELAY

DESCRIPTION: REED

ENVIRONMENT	FAILURES	PART HOURS ( $10^6$ )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
					LOW	HIGH
<u>NON-OPERATING</u>						
GROUND, FIXED	*	*	8.5	17.0	-	637
<u>OPERATING</u>						
SATELLITE	-	-	-	-	-	
GROUND	15	81.5	184.	262.	-	
GROUND, MOBILE	-	-	-	-	-	
AIRBORNE	-	-	-	-	-	
MISSILE	-	-	-	-	-	
SHIPBOARD	39	19.77	1973.	2444.	-	
SUBMARINE	-	-	-	-	-	
HELICOPTER	-	-	-	-	-	

ENVIRONMENTAL FACTORS								
NON-OPERATING			OPERATING					
G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
1.0	-	22.	-	-	-	232.	-	-

\* See Relay, General

PART CATEGORY: RELAY

DESCRIPTION: THERMAL

ENVIRONMENT	FAILURES	PART HOURS ( $10^6$ )	FAILURE RATE IN FITS			RANGE
			BEST ESTIMATE	90% CONFIDENCE	LOW	
<u>NON-OPERATING</u>						
GROUND, FIXED	*	*	8.5	17.0	-	637.
<u>OPERATING</u>						
SATELLITE	-	-	-	-	-	
GROUND	5	.382	13089.	24465.	-	
GROUND, MOBILE	-	-	-	-	-	
AIRBORNE	1	.039	25641.	99771.	-	
MISSILE	-	-	-	-	-	
SHIPBOARD	2	2.68	746.	1985.	-	
SUBMARINE	-	-	-	-	-	
HELICOPTER	-	-	-	-	-	

ENVIRONMENTAL FACTORS

NON-OPERATING	OPERATING								
	G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
	1.0	-	1540	-	3017	-	88.	-	-

\* See Relay, General

PART CATEGORY: RELAY

DESCRIPTION: TIME DELAY

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
<u>NON-OPERATING</u>						
GROUND, FIXED	*	*	8.5	17.0	-	637.
<u>OPERATING</u>						
SATELLITE	-	-	-	-		
GROUND	10	6.918	1446.	2231.		
GROUND, MOBILE	2	.471	4246.	11293.		
AIRBORNE	23	1.333	17254.	22802.		
MISSILE	-	-	-	-		
SHIPBOARD	55	34.39	1599.	1913.		
SUBMARINE	3	4.45	674.	1498.		
HELICOPTER						

ENVIRONMENTAL FACTORS									
NON-OPERATING		OPERATING							
G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H	
1.0	-	170	500	2030	-	188	79	-	

\* See Relay, General

PART CATEGORY: SWITCH

DESCRIPTION: GENERAL

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			RANGE	
			BEST ESTIMATE	90% CONFIDENCE	LOW		
<b><u>NON-OPERATING</u></b>							
GROUND, FIXED	11	133.	82.8	125.3	-	291.	
<b><u>OPERATING</u></b>							
SATELLITE	4	7.88	508.	1015.			
GROUND	0	1.347	<742.	1715.			
GROUND, MOBILE	-	-	-	-			
AIRBORNE	1100	10.28	107004.	111253.			
MISSILE	-	-	-	-			
SHIPBOARD	-	-	-	-			
SUBMARINE	2	3.952	506.	1346.			
HELICOPTER	348	3.528	98639.	105752.			

ENVIRONMENTAL FACTORS

NON-OPERATING	OPERATING								
	G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
	1.0	6.	9.	-	1292.	-	-	6.	1191.

PART CATEGORY: SWITCH

DESCRIPTION: PRESSURE

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
<b>NON-OPERATING</b>						
GROUND, FIXED	4	73.8	54.2	108.4		323.
<b>OPERATING</b>						
SATELLITE	-	-	-	-		
GROUND	100	47.74	2095.	2388.		
GROUND, MOBILE	105	17.18	6112.	6946.		
AIRBORNE	1929	34.43	56027.	57695.		
MISSILE	-	-	-	-		
SHIPBOARD	18	.798	22556.	31018.		
SUBMARINE	4	.613	6525.	13051.		
HELICOPTER	348	1.047	33237.	356344.		

ENVIRONMENTAL FACTORS

NON-OPERATING	OPERATING								
	G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
	1.0	-	39	11.3	1034	-	416	120	6132

\* See Switch, General

PART CATEGORY: SWITCH

DESCRIPTION: PUSHBUTTON

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			RANGE	LOW	HIGH
			BEST ESTIMATE	90% CONFIDENCE				
<b>NON-OPERATING</b>								
GROUND, FIXED	1	38.5	26.0	101.1	-	-	58.8	
<b>OPERATING</b>								
SATELLITE	-	-	-	-	-	-		
GROUND	6	22.18	271.	476.				
GROUND, MOBILE	-	-	-	-	-	-		
AIRBORNE	101	3.624	27870.	31757.				
MISSILE	-	-	-	-	-	-		
SHIPBOARD	55	120.2	458.	547.				
SUBMARINE	7	89.88	78.	131.				
HELICOPTER	0	1.286	<778.	1796.				

ENVIRONMENTAL FACTORS									
NON-OPERATING		OPERATING							
G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H	
1.0	-	10	-	1072	-	18	3	30	

\* See Switch, General

PART CATEGORY: SWITCH

DESCRIPTION: ROTARY

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			RANGE	
			BEST ESTIMATE	90% CONFIDENCE	LOW	HIGH	
<u>NON-OPERATING</u>							
GROUND, FIXED	*	*	82.8	125.3	-	291.	
<u>OPERATING</u>							
SATELLITE	1	2.391	418.	1627.			
GROUND	48	36.11	1329.	1610.			
GROUND, MOBILE	-	-	-	-			
AIRBORNE	261	14.75	17695.	19179.			
MISSILE	-	-	-	-			
SHIPBOARD	80	52.1	1536.	1777.			
SUBMARINE	32	20.2	1584.	2004.			
HELICOPTER	2	.092	21739.	57817.			

ENVIRONMENTAL FACTORS

NON-OPERATING	OPERATING								
	G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
	1.0	5	16	-	214	-	19	19	263

\* See Switch, General

PART CATEGORY: SWITCH

DESCRIPTION: SENSITIVE

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			RANGE
			BEST ESTIMATE	90% CONFIDENCE		
					LOW	HIGH
<u>NON-OPERATING</u>						
GROUND, FIXED	*	*	82.8	125.3	-	291.
<u>OPERATING</u>						
SATELLITE	-	-	-	-	-	
GROUND	13	11.47	1133.	1654.	-	
GROUND, MOBILE	-	-	-	-	-	
AIRBORNE	184	12.56	14650.	16129.	-	
MISSILE	2	.008	250000.	664894.	-	
SHIPBOARD	-	-	-	-	-	
SUBMARINE	51	45.93	1110.	1336.	-	
HELICOPTER	3	.61	4918.	10929.	-	

ENVIRONMENTAL FACTORS									
NON-OPERATING		OPERATING							
G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H	
1.0	-	14	-	177	3019	-	13	59	

\*See Switch, Sensitive

PART CATEGORY: SWITCH

DESCRIPTION: THERMOSTATIC

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
<b>NON-OPERATING</b>						
GROUND, FIXED	1	58.5	17.1	66.6	-	29.4
<b>OPERATING</b>						
SATELLITE	-	-	-	-		
GROUND	11	4.381	2511.	3798.		
GROUND, MOBILE	-	-	-	-		
AIRBORNE	44	6.733	6535.	7985.		
MISSILE	-	-	-	-		
SHIPBOARD	29	45.77	634.	812.		
SUBMARINE	7	1.838	3808.	6416.		
HELICOPTER	9	.218	41284.	65251.		

ENVIRONMENTAL FACTORS

NON-OPERATING	OPERATING								
	G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
	1.0	-	147	-	382	-	37	223	2414

\* See Switch, General

PART CATEGORY: SWITCH

DESCRIPTION: TOGGLE

ENVIRONMENT	FAIL- URES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			RANGE
			BEST ESTIMATE	90% CONFI- DENCE	LOW	
<b>NON-OPERATING</b>						
GROUND, FIXED	*	*	26.0	101.1	-	58.8
<b>OPERATING</b>						
SATELLITE	-	-	-	-	-	
GROUND	135	237.5	568.	636.		
GROUND, MOBILE	1	.359	2786.	10839.		
AIRBORNE	255	35.45	7193.	7804.		
MISSILE	-	-	-	-		
SHIPBOARD	67	141.4	474.	557.		
SUBMARINE	-	-	-	-		
HELICOPTER	8	.43	18605.	30242.		

ENVIRONMENTAL FACTORS									
NON-OPERATING		OPERATING							
G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H	
1.0	-	22	107	277	-	18	-	716	

\* See Switch, Pushbutton

PART CATEGORY: SWITCH  
 DESCRIPTION: STEPPING

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			RANGE
			BEST ESTIMATE	90% CONFIDENCE	LOW	
<u>NON-OPERATING</u>						
GROUND, FIXED	2	5.0	400.	1064.		
<u>OPERATING</u>						
SATELLITE						
GROUND						
GROUND, MOBILE						
AIRBORNE						
MISSILE						
SHIPBOARD	5	.234	21368.	39939.		
SUBMARINE						
HELICOPTER						

ENVIRONMENTAL FACTORS								
NON-OPERATING			OPERATING					
G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
1.0						53.		

PART CATEGORY: SWITCH

DESCRIPTION: SOLENOID

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			RANGE
			BEST ESTIMATE	90% CONFIDENCE	LOW	
			HIGH			
<u>NON-OPERATING</u>						
GROUND, FIXED	9	82.4	109.3	172.7		
<u>OPERATING</u>						
SATELLITE	1	1.399	715.	2781.		
GROUND	3	.033	90909.	202020		
GROUND, MOBILE						
AIRBORNE	612	9.847	62151.	65490.		
MISSILE						
SHIPBOARD						
SUBMARINE	6	.234	25641.	45079.		
HELICOPTER	3	.03	100000.	222222.		

ENVIRONMENTAL FACTORS

NON-OPERATING

OPERATING

G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
1.0	6.5	832		569			235	915

PART CATEGORY: SWITCH

DESCRIPTION: MOTOR DRIVEN S&A

ENVIRONMENT	FAILURES	PART HOURS ( $10^6$ )	FAILURE RATE IN FITS			RANGE
			BEST ESTIMATE	90% CONFIDENCE	LOW	
<u>NON-OPERATING</u>						
GROUND, FIXED	9	65.1	138.2	218.5		
<u>OPERATING</u>						
SATELLITE						
GROUND						
GROUND, MOBILE						
AIRBORNE						
MISSILE						
SHIPBOARD						
SUBMARINE						
HELICOPTER						

ENVIRONMENTAL FACTORS

NON-OPERATING

OPERATING

$G_F$

1.0

$S_A$

$G$

$G_M$

$A$

$M$

$S_H$

$S_U$

$H$

PART CATEGORY: SWITCH

DESCRIPTION: INERTIAL

ENVIRONMENT	FAILURES	PART HOURS ( $10^6$ )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
<u>NON-OPERATING</u>						
GROUND, FIXED	12	180.6	66.4	98.7	65.6	1130.
<u>OPERATING</u>						
SATELLITE						
GROUND						
GROUND, MOBILE						
AIRBORNE						
MISSILE						
SHIPBOARD						
SUBMARINE						
HELICOPTER						

ENVIRONMENTAL FACTORS

NON-OPERATING

OPERATING

$G_F$

$S_A$

G

$G_M$

A

M

$S_H$

$S_U$

H

1.0

PART CATEGORY: ROTATING ELECTROMECHANICAL DEVICES

DESCRIPTION: AC GENERATOR

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			RANGE
			BEST ESTIMATE	90% CONFIDENCE	LOW	
<u>NON-OPERATING</u>						
GROUND, FIXED	11	13.8	795.5	1203		
<u>OPERATING</u>						
SATELLITE						
GROUND	0	.002	<500000	1154734		
GROUND, MOBILE	45	.086	523256	638896		
AIRBORNE	6017	5.444	1105253	1123727		
MISSILE						
SHIPBOARD	8	.341	23460	38135		
SUBMARINE						
HELICOPTER	7	.015	466667	786164		

ENVIRONMENTAL FACTORS

NON-OPERATING

OPERATING

G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S	H
1.0		629	558	1389		29		587

PART CATEGORY: ROTATING ELECTROMECHANICAL DEVICES

DESCRIPTION: SLIP RING ASSEMBLY

ENVIRONMENT	FAIL- URES	PART HOURS ( $10^6$ )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFI- DENCE	RANGE	
					LOW	HIGH
<u>NON-OPERATING</u>						
GROUND, FIXED	0	8.3	<120.1	277		
<u>OPERATING</u>						
SATELLITE	0	.408	<2451	5660		
GROUND	0	.437	<2288	5285		
GROUND, MOBILE	103	2.065	49879	56762		
AIRBORNE						
MISSILE						
SHIPBOARD						
SUBMARINE	39	.977	39918	49446		
HELICOPTER	3	.014	214286	476190		

ENVIRONMENTAL FACTORS									
NON-OPERATING		OPERATING							
G <sub>F</sub>	S <sub>A</sub>	G <sub>L</sub>	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H	
1.0	20	19	415				332	1784	

PART CATEGORY: ROTATING ELECTROMECHANICAL DEVICES

DESCRIPTION: TORQUER MOTOR

ENVIRONMENT	FAILURES	PART HOURS ( $10^6$ )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
<u>NON-OPERATING</u>						
GROUND, FIXED	14	45.3	308.8	445.	-	340
<u>OPERATING</u>						
SATELLITE						
GROUND	0	.219	<4566.	10546.		
GROUND, MOBILE						
AIRBORNE						
MISSILE						
SHIPBOARD						
SUBMARINE	0	2.153	464	1073.		
HELICOPTER						

ENVIRONMENTAL FACTORS									
NON-OPERATING			OPERATING						
$G_F$	$S_A$	$G$	$G_M$	$A$	$M$	$S_H$	$S_U$	$H$	
1.0		15					1.5		

PART CATEGORY: ROTATING ELECTROMECHANICAL DEVICES

DESCRIPTION: RESOLVERS & SYNCHROS

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			RANGE
			BEST ESTIMATE	90% CONFIDENCE	LOW	
<u>NON-OPERATING</u>						
GROUND, FIXED	2	14.2	140.9	375.		
<u>OPERATING</u>						
SATELLITE						
GROUND	18	.976	18443.	25361.		
GROUND, MOBILE	29	6.908	4198.	5381.		
AIRBORNE	18.	.625	28800.	39604.		
MISSILE						
SHIPBOARD	2.	.036	55556.	147754.		
SUBMARINE	3	8.506	353.	784.		
HELICOPTER	15	.1	150000.	213220.		

ENVIRONMENTAL FACTORS									
NON-OPERATING			OPERATING						
G <sub>F</sub>	S <sub>A</sub>	C	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H	
1.0		131	30	204		394	2.5	1065	

PART CATEGORY: ROTATING ELECTROMECHANICAL DEVICES

DESCRIPTION: AC MOTOR

ENVIRONMENT	FAILURES	PART HOURS ( $10^6$ )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
					LOW	HIGH
<u>NON-OPERATING</u>						
GROUND, FIXED	1	2.3	431.6	1679	-	499
<u>OPERATING</u>						
SATELLITE						
GROUND	9	4.164	2161.	3416		
GROUND, MOBILE	184	24.37	7550.	8313		
AIRBORNE						
MISSILE						
SHIPBOARD						
SUBMARINE						
HELICOPTER						

ENVIRONMENTAL FACTORS

NON-OPERATING	OPERATING								
	$G_F$	$S_A$	G	$G_M$	A	M	$S_H$	$S_U$	H
	1.0		5.0	17.					

PART CATEGORY: ROTATING ELECTROMECHANICAL DEVICES

DESCRIPTION: DC MOTOR

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			RANGE
			BEST ESTIMATE	90% CONFIDENCE	LOW	
<u>NON-OPERATING</u>						
GROUND, FIXED	3.	87.1	34.4	77	-	4702
<u>OPERATING</u>						
SATELLITE						
GROUND	0	.264	<3788.	8748		
GROUND, MOBILE	2	2.524	792.	2107		
AIRBORNE	75	.907	82690	95873		
MISSILE						
SHIPBOARD	1	.003	333333	1297017		
SUBMARINE	702	56.1	12513	13140		
HELICOPTER	2	.051	39216	104297		

ENVIRONMENTAL FACTORS

NON-OPERATING	OPERATING								
	G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
	1.0		110	23	2404		9690	364	1140

PART CATEGORY: ROTATING ELECTROMECHANICAL DEVICES

DESCRIPTION: BLOWERS & FANS

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			RANGE	
			BEST ESTIMATE	90% CONFIDENCE	LOW	HIGH	
<u>NON-OPERATING</u>							
GROUND, FIXED	0	27.7	36.1	83.			
<u>OPERATING</u>							
SATELLITE							
GROUND	46	32.3	1424.	1730.			
GROUND, MOBILE	108	19.1	5654.	6415.			
AIRBORNE	2132	48.6	43868.	45110.			
MISSILE							
SHIPBOARD	112	6.07	18451.	20884.			
SUBMARINE	5	10.95	457.	853.			
HELICOPTER	173	2.03	85222.	94115.			

ENVIRONMENTAL FACTORS

NON-OPERATING

OPERATING

G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
1.0		39	157	1215		511	13	2361

PART CATEGORY: TRANSDUCER

DESCRIPTION: PRESSURE

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			RANGE
			BEST ESTIMATE	90% CONFIDENCE	LOW	
<u>NON-OPERATING</u>						
GROUND, FIXED	4	2.1	1905	3810		
<u>OPERATING</u>						
SATELLITE						
GROUND	14	.186	75269	108394		
GROUND, MOBILE	97	1.227	79055	90326		
AIRBORNE	902	9.543	94520	98676		
MISSILE						
SHIPBOARD						
SUBMARINE						
HELICOPTER	92	.595	154622	177315		

ENVIRONMENTAL FACTORS									
NON-OPERATING			OPERATING						
G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H	
1.0		40	41	50				81	

PART CATEGORY: ANTENNA ASSEMBLY

DESCRIPTION:

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
<u>NON-OPERATING</u>						
GROUND, FIXED	1	85.7	11.7	45.4		
<u>OPERATING</u>						
SATELLITE	0	.545	<1835.	4238.		
GROUND	9	.001	9000000.	1422475	1	
GROUND, MOBILE						
AIRBORNE	1560	17.289	90231.	93226		
MISSILE						
SHIPBOARD						
SUBMARINE						
HELICOPTER	137	1.172	116894	130718		

ENVIRONMENTAL FACTORS

NON-OPERATING

OPERATING

G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
1.0	157	769231	7712					9991

## PART CATEGORY: ROTARY INVERTER

## DESCRIPTION:

ENVIRONMENT	FAIL- URES	PART HOURS ( $10^6$ )	FAILURE RATE IN FITS			RANGE
			BEST ESTIMATE	90% CONFI- DENCE	LOW	
			HIGH			
<u>NON-OPERATING</u>						
GROUND, FIXED	0	21.6	<46.3	107.		
<u>OPERATING</u>						
SATELLITE						
GROUND						
GROUND, MOBILE						
AIRBORNE						
MISSILE						
SHIPBOARD						
SUBMARINE						
HELICOPTER						

ENVIRONMENTAL FACTORS								
NON-OPERATING			OPERATING					
<u>G<sub>F</sub></u>	<u>S<sub>A</sub></u>	<u>G</u>	<u>G<sub>M</sub></u>	<u>A</u>	<u>M</u>	<u>S<sub>H</sub></u>	<u>S<sub>U</sub></u>	<u>H</u>
1.0								

PART CATEGORY: ACCUMULATORS

- Diaphragm Separator
- Bag-Type Separator
- Piston Type Separator
- Class 1500 and 3000

DESCRIPTION: GENERAL

ENVIRONMENT	FAIL- URES	PAKT HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFI- DENCE	RANGE	
					LOW	HIGH
<b>NON-OPERATING</b>						
GROUND, FIXED	7	215.	32.5	54.8	-	120.
<b>OPERATING</b>						
SATELLITE	0	.054	18500.	42800.		
GROUND	1	.004	250000.	973000.		
GROUND, MOBILE	2	.067	29800.	79400.		
AIRBORNE	36	2.031	17700.	22100.		
MISSILE	-	-	-	-		
SHIPBOARD	-	-	-	-		
SUBMARINE	-	-	-	-		
HELICOPTER	7	.014	500000.	842000.		

#### ENVIRONMENTAL FACTORS

NON-OPERATING	OPERATING								
	G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
	1.0	570	7700	910	540	-	-	-	15000

\*See Hydraulic Accumulators

PART CATEGORY: ACCUMULATORS

DESCRIPTION: HYDRAULIC

ENVIRONMENT	FAIL- URES	PART HOURS ( $10^6$ )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFI- DENCE	RANGE	
					LOW	HIGH
<u>NON-OPERATING</u>						
GROUND, FIXED	7	215.01	32.6	54.8	-	120.
<u>OPERATING</u>						
SATELLITE	71	47.22	1500.	1760		
GROUND	664	11.888	55800	58700		
GROUND, MOBILE	129	8.604	15000	16800		
AIRBORNE	1396	11.803	118000	122000		
MISSILE	71	47.22	1500	1760		
SHIPBOARD	-	-	-	-		
SUBMARINE	-	-	-	-		
HELICOPTER	45	.560	80300	98100		

ENVIRONMENTAL FACTORS									
NON-OPERATING		OPERATING							
G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H	
1.0	46	1700	460	3600	46	-	-	2500	

PART CATEGORY: ACTUATORS

DESCRIPTION: GENERAL

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
<u>NON-OPERATING</u>						
GROUND, FIXED	142	847.6	167.	187.	9.8	27300.
<u>OPERATING</u>						
SATELLITE	-	-	-	-		
GROUND	-	-	-	-		
GROUND, MOBILE	-	-	-	-		
AIRBORNE	384	7.625	50400.	53800.		
MISSILE	-	-	-	-		
SHIPBOARD	-	-	-	-		
SUBMARINE	-	-	-	-		
HELICOPTER	273	.383	712794.	787581		

ENVIRONMENTAL FACTORS

NON-OPERATING

OPERATING

G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
1.0	-	-	-	302	-	-	-	4268

PART CATEGORY:	ACTUATORS, LINEAR	
DESCRIPTION:	ELECTRICAL (GENERAL)	Electropneumatic Electrohydraulic

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
					LOW	HIGH
<u>NON-OPERATING</u>						
GROUND, FIXED	*	*	167.	187.	9.8	27300
<u>OPERATING</u>						
SATELLITE	-	-	-	-		
GROUND	-	-	-	-		
GROUND, MOBILE	-	-	-	-		
AIRBORNE	747	11.158	66900.	70200		
MISSILE	-	-	-	-		
SHIPBOARD	-	-	-	-		
SUBMARINE	-	-	-	-		
HELICOPTER	273	.383	712794.	787581		

ENVIRONMENTAL FACTORS									
NON-OPERATING			OPERATING						
G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H	
1.0	-	-	-	360	-	-	-	4268	

\* See Actuators, General

PART CATEGORY: ACTUATORS  
 DESCRIPTION: HYDRAULIC (General)

- Linear
- Rotary
- Piston
- Plunger
- Vane

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			RANGE	
			BEST ESTIMATE	90% CONFIDENCE			
			LOW	HIGH			
<b>NON-OPERATING</b>							
GROUND, FIXED	121	608.6	199	269	9.8	27300	
<b>OPERATING</b>							
SATELLITE	-	-	-	-	-	-	
GROUND	3	.197	15200	33800			
GROUND, MOBILE	38	.713	53300	66200			
AIRBORNE	16407	119.9	137000	138000			
MISSILE	-	-	-	-	-	-	
SHIPBOARD	-	-	-	-	-	-	
SUBMARINE	5	.467	10700	20000			
HELICOPTER	129	1.197	108000	121000			

ENVIRONMENTAL FACTORS									
NON-OPERATING					OPERATING				
G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H	
1.0	-	76	270	690	-	-	54	540	

PART CATEGORY: ACTUATORS, LINEAR

DESCRIPTION: HYDRAULIC SERVO

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
<b>NON-OPERATING</b>						
GROUND, FIXED	*	*	199	269	9.8	27300
<b>OPERATING</b>						
SATELLITE	-	-	-	-	-	
GROUND	51	.406	126000	151000		
GROUND, MOBILE	-	-	-	-		
AIRBORNE	1404	10.765	130000	135000		
MISSILE	-	-	-	-		
SHIPBOARD	-	-	-	-		
SUBMARINE	-	-	-	-		
HELICOPTER	82	.764	107000	125000		

ENVIRONMENTAL FACTORS

NON-OPERATING	OPERATING								
	G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
	1.0	-	630	-	650	-	-	-	540

\* See Actuator, Hydraulic, General

PART CATEGORY: ACTUATORS, LINEAR  
 DESCRIPTION: MECHANICAL DRIVEN

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
<u>NON-OPERATING</u>						
GROUND, FIXED	*	*	167	187	9.8	27300
<u>OPERATING</u>						
SATELLITE	-	-	-	-		
GROUND	-	-	-	-		
GROUND, MOBILE	-	-	-	-		
AIRBORNE	1144	19.739	58000	60200		
MISSILE	-	-	-	-		
SHIPBOARD	-	-	-	-		
SUBMARINE	-	-	-	-		
HELICOPTER	-	-	-	-		

ENVIRONMENTAL FACTORS								
NON-OPERATING			OPERATING					
G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
1.0	-	-	-	350	-	-	-	-

\*See Actuator, General

PART CATEGORY:	ACTUATORS	• Control
DESCRIPTION:	PNEUMATIC, GENERAL & LINEAR	• Springless
		• Diaphragm

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
<u>NON-OPERATING</u>						
GROUND, FIXED	21	239	87.9	118	63.	256.
<u>OPERATING</u>						
SATELLITE	-	-	-	-	-	-
GROUND (cycles)	13	1.074	12104.0	19227	-	-
GROUND, MOBILE	-	-	-	-	-	-
AIRBORNE	1250	6.127	204000.	212000.	-	-
MISSILE	-	-	-	-	-	-
SHIPBOARD	-	-	-	-	-	-
SUBMARINE	-	-	-	-	-	-
HELICOPTER	-	-	-	-	-	-

ENVIRONMENTAL FACTORS									
NON-OPERATING		OPERATING							
G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H	
1.0	-	-	-	2300	-	-	-	-	-

PART CATEGORY: ACTUATOR, LINEAR  
 DESCRIPTION: PNEUMATIC, PISTON  
 ROLLING DIAPHRAGM

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			RANGE	
			BEST ESTIMATE	90% CONFIDENCE	LOW	HIGH	
<u>NON-OPERATING</u>							
GROUND, FIXED	*	*	87.9	118	63	256	
<u>OPERATING</u>							
SATELLITE	-	-	-	-	-	-	
GROUND	10	6.636	1510.	2320	-	-	
GROUND, MOBILE	-	-	-	-	-	-	
AIRBORNE	-	-	-	-	-	-	
MISSILE	-	-	-	-	-	-	
SHIPBOARD	-	-	-	-	-	-	
SUBMARINE	-	-	-	-	-	-	
HELICOPTER	82	.764	107330.	128783.	-	-	

ENVIRONMENTAL FACTORS									
NON-OPERATING			OPERATING						
G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H	
1.0	-	17	-	-	-	-	-	-	1221.0

\*See Actuator, Pneumatic, General

PART CATEGORY: ACTUATOR, ROTARY

DESCRIPTION: GENERAL

ENVIRONMENT	FAIL- URES	PART HOURS ( $10^6$ )	FAILURE RATE IN FITS			RANGE	
			BEST ESTIMATE	90% CONFI- DENCE			
			LOW	HIGH			
<u>NON-OPERATING</u>							
GROUND, FIXED	*	*	167	187	9.8	27300	
<u>OPERATING</u>							
SATELLITE	-	-	-	-	-		
GROUND	-	-	-	-	-		
GROUND, MOBILE	-	-	-	-	-		
AIRBORNE	445	2.585	172000	183000			
MISSILE	-	-	-	-	-		
SHIPBOARD	-	-	-	-	-		
SUBMARINE	-	-	-	-	-		
HELICOPTER	-	-	-	-	-		

ENVIRONMENTAL FACTORS

NON-OPERATING	OPERATING								
	G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
	1.0	-	-	-	1030	-	-	-	-

\*See Actuator, General

PART CATEGORY:	ACTUATOR, ROTARY
DESCRIPTION:	ELECTRICAL

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
<u>NON-OPERATING</u>						
GROUND, FIXED	*	*	167.	187	9.8	27300
<u>OPERATING</u>						
SATELLITE	-	-	-	-	-	-
GROUND	-	-	-	-	-	-
GROUND, MOBILE	-	-	-	-	-	-
AIRBORNE	0	.117	8850.	19700	-	-
MISSILE	-	-	-	-	-	-
SHIPBOARD	-	-	-	-	-	-
SUBMARINE	0	1.893	484.0	1221.	-	-
HELICOPTER	-	-	-	-	-	-

ENVIRONMENTAL FACTORS									
NON-OPERATING			OPERATING						
G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H	
1.0	-	-	-	51	-	-	3	-	-

\* See Actuator, General

PART CATEGORY: BATTERIES  
 DESCRIPTION: SILVER/ZINC

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
					LOW	HIGH
<u>NON-OPERATING</u>						
GROUND, FIXED	0	23.6	<42.4	97.9		
<u>OPERATING</u>						
SATELLITE						
GROUND						
GROUND, MOBILE						
AIRBORNE						
MISSILE						
SHIPBOARD						
SUBMARINE						
HELICOPTER						

ENVIRONMENTAL FACTORS								
NON-OPERATING			OPERATING					
G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
1.0								

PART CATEGORY: BATTERIES

DESCRIPTION: THERMAL

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			RANGE	
			BEST ESTIMATE	90% CONFIDENCE			
			LOW	HIGH			
<u>NON-OPERATING</u>							
GROUND, FIXED	1	10.6	94.3	367.			
<u>OPERATING</u>							
SATELLITE							
GROUND							
GROUND, MOBILE							
AIRBORNE							
MISSILE							
SHIPEBOARD							
SUBMARINE							
HELICOPTER							

ENVIRONMENTAL FACTORS

NON-OPERATING

OPERATING

G<sub>F</sub>

S<sub>A</sub>

G

G<sub>M</sub>

A

M

S<sub>H</sub>

S<sub>U</sub>

H

1.0

PART CATEGORY: BATTERIES  
 DESCRIPTION: RECHARGEABLE

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS		
			BEST ESTIMATE	90% CONFIDENCE	RANGE
NON-OPERATING					
GROUND, FIXED					
OPERATING					
SATELLITE	8	60.591	132.0	238.	
GROUND	8	5.339	1498.0	2706.	
GROUND, MOBILE	4	0.148	27027.	61824.	
AIRBORNE	2810	8.055348852.	359855.		
MISSILE					
SHIPBOARD					
SUBMARINE					
HELICOPTER	201	0.297676768.	760242.		

ENVIRONMENTAL FACTORS								
NON-OPERATING			OPERATING					
G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
1.0	3	35	637	8019				15961

PART CATEGORY: BATTERIES

DESCRIPTION: RECHARGEABLE, SOLAR

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS		
			BEST ESTIMATE	90% CONFIDENCE	RANGE
LOW	HIGH				
<u>NON-OPERATING</u> GROUND, FIXED					
<u>OPERATING</u> SATELLITE	8	7483.	1.1	1.9	
GROUND					
GROUND, MOBILE					
AIRBORNE					
MISSILE					
SHIPBOARD					
SUBMARINE					
HELICOPTER					

ENVIRONMENTAL FACTORS

NON-OPERATING

OPERATING

G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>T</sub>	H
1.0								

PART CATEGORY: BEARING

DESCRIPTION: GENERAL

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
<u>NON-OPERATING</u>						
GROUND, FIXED	*	*	14.5	23.5	5.0	2990
<u>OPERATING</u>						
SATELLITE	-	-	-	-		
GROUND	32	15.547	2060.	2600.		
GROUND, MOBILE	34	1.551	21900.	27600.		
AIRBORNE	268	32.677	8200.	8870.		
MISSILE	-	-	-	-		
SHIPBOARD	-	-	-	-		
SUBMARINE	-	-	-	-		
HELICOPTER	200	12.364	16200.	17700.		

ENVIRONMENTAL FACTORS

NON-OPERATING	OPERATING								
	G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
	1.0	-	140	1500	560	-	-	-	1100

\*See Bearing, Ball

PART CATEGORY: BEARING

DESCRIPTION: BALL

ENVIRONMENT	FAILURES	PART HOURS ( $10^6$ )	FAILURE RATE IN FITS			RANGE	
			BEST ESTIMATE	90% CONFIDENCE	LOW		
<u>NON-OPERATING</u>							
GROUND, FIXED	8	552.5	14.5	23.5	5.0	2990.	
<u>OPERATING</u>							
SATELLITE	0	1.332	<751	1730			
GROUND	27	28.532	946	1220			
GROUND, MOBILE	4	42.554	94	188			
AIRBORNE	200	58.48	3420	3750			
MISSILE	-	-	-	-			
SHIPBOARD	2	.022	<45500	105000			
SUBMARINE	2	.423	4730	12600			
HELICOPTER	22	1.642	13400	17800			

ENVIRONMENTAL FACTORS

NON-OPERATING	OPERATING								
	G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
	1.0	52	65	6	240	-	3100	330	920

PART CATEGORY: BEARING

DESCRIPTION: NEEDLE

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
					LOW	HIGH
<u>NON-OPERATING</u>						
GROUND, FIXED	*	*	14.5	23.5	5.	2990.
<u>OPERATING</u>						
SATELLITE	-	-	-	-		
GROUND	-	-	-	-		
GROUND, MOBILE	-	-	-	-		
AIRBORNE	0	.337	<2970.	6850.		
MISSILE	-	-	-	-		
SHIPBOARD	-	-	-	-		
SUBMARINE	-	-	-	-		
HELICOPTER	-	-	-	-		

#### ENVIRONMENTAL FACTORS

NON-OPERATING	OPERATING								
	G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
	1.0	-	-	-	200	-	-	-	-

\*See Bearing, Ball

PART CATEGORY: BEARING

DESCRIPTION: ROLLER

ENVIRONMENT	FAIL- URES	PART HOURS ( $10^6$ )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFI- DENCE	RANGE	
					LOW	HIGH
<u>NON-OPERATING</u>						
GROUND, FIXED	*	*	14.5	23.5	5.0	2990
<u>OPERATING</u>						
SATELLITE	-	-	-	-	-	
GROUND	8	28.562	280.	455.		
GROUND, MOBILE	-	-	-	-		
AIRBORNE	11	38.774	284	429.		
MISSILE	-	-	-	-		
SHIPBOARD	4	3.317	1210	2410		
SUBMARINE	-	-	-	-		
HELICOPTER	6	.25	24000	42200		

ENVIRONMENTAL FACTORS									
NON-OPERATING			OPERATING						
G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H	
1.0	-	19	-	20	-	83	-	1600	

\*See Bearing, Ball

PART CATEGORY: BEARING  
 DESCRIPTION: SPHERICAL

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
<u>NON-OPERATING</u>						
GROUND, FIXED	*	*	14.5	23.5	5.	2990
<u>OPERATING</u>						
SATELLITE	-	-	-	-		
GROUND	-	-	-	-		
GROUND, MOBILE	22	106.73	206.	274.		
AIRBORNE	429	67.18	6380.	6790.		
MISSILE	-	-	-	-		
SHIPBOARD	-	-	-	-		
SUBMARINE	-	-	-	-		
HELICOPTER	168	6.313	26600.	29400.		

ENVIRONMENTAL FACTORS									
NON-OPERATING			OPERATING						
G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H	
1.0	-	-	14	440	-	-	-	1800	

\*See Bearing, Ball

PART CATEGORY: BEARING

DESCRIPTION: SLEEVE

ENVIRONMENT	FAIL- URES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			RANGE	
			BEST ESTIMATE	90% CONFIDENCE	LOW	HIGH	
<u>NON-OPERATING</u>							
GROUND, FIXED	*	*	14.5	23.5	5.	2990.	
<u>OPERATING</u>							
SATELLITE	-	-	-	-	-		
GROUND	-	-	-	-	-		
GROUND, MOBILE	-	-	-	-	-		
AIRBORNE	-	-	-	-	-		
MISSILE	-	-	-	-	-		
SHIPBOARD	-	-	-	-	-		
SUBMARINE	-	-	-	-	-		
HELICOPTER	2	.05	40000.	106000.			

ENVIRONMENTAL FACTORS

NON-OPERATING	OPERATING								
	G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
	1.0	-	-	-	-	-	-	-	2800

\*See Bearing, Ball

PART CATEGORY: COMPRESSOR

DESCRIPTION: GENERAL

ENVIRONMENT	FAIL- URES	PART HOURS ( $10^6$ )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
					LOW	HIGH
<u>NON-OPERATING</u>						
GROUND, FIXED	0	.248	<4080	9430	-	-
<u>OPERATING</u>						
SATELLITE	-	-	-	-	-	-
GROUND	16	1.259	12700	17800	-	-
GROUND, MOBILE	-	-	-	-	-	-
AIRBORNE	2217	7.47	297000	305000	-	-
MISSILE	-	-	-	-	-	-
SHIPBOARD	-	-	-	-	-	-
SUBMARINE	-	-	-	-	-	-
HELICOPTER	15	.03	500000	711000	-	-

ENVIRONMENTAL FACTORS									
NON-OPERATING		OPERATING							
G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H	
1.0	-	3	-	73	-	-	-	120	

PART CATEGORY: CYLINDER

° Type I, II, III & IV

Systems

DESCRIPTION: GENERAL

° Class 3000

ENVIRONMENT	FAIL- URES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			RANGE	
			BEST ESTIMATE	90% CONFI- DENCE	RANGE		
					LOW	HIGH	
<u>NON-OPERATING</u>							
GROUND, FIXED	12	160	75.	111.	-	-	
<u>OPERATING</u>							
SATELLITE	-	-	-	-			
GROUND	27	.814	33200.	42900.			
GROUND, MOBILE	-	-	-	-			
AIRBORNE	9841	46.38	212000	215000.			
MISSILE	-	-	-	-			
SHIPBOARD	-	-	-	-			
SUBMARINE	-	-	-	-			
HELICOPTER	142	.146	973000.	1080000			

#### ENVIRONMENTAL FACTORS

NON-OPERATING	OPERATING								
	G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
	1.0	-	440	-	2800	-	-	-	13000

PART CATEGORY: FILTER, NONELECTRIC

DESCRIPTION: GENERAL

ENVIRONMENT	FAIL- URES	PART HOURS ( $10^6$ )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFI- DENCE	RANGE	
					LOW	HIGH
<u>NON-OPERATING</u>						
GROUND, FIXED	0	706.51	< 1.42	3.26	-	-
<u>OPERATING</u>						
SATELLITE	0	4.45	< 225.	519.		
GROUND	0	.085	11800.	27200.		
GROUND, MOBILE	55	.746	73700.	88200.		
AIRBORNE	71	21263.	3.34	3.92		
MISSILE	-	-	-	-		
SHIPBOARD	-	-	-	-		
SUBMARINE	-	-	-	-		
HELICOPTER	32	16.07	1990.	2520.		

ENVIRONMENTAL FACTORS

NON-OPERATING	OPERATING							
$G_F$	$S_A$	$G$	$G_M$	$A$	$M$	$S_H$	$S_U$	$H$
1.0	160	8300	52000	2	-	-	-	1400

PART CATEGORY: FILTER, NONELECTRIC

DESCRIPTION: GASEOUS

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
					LOW	HIGH
<u>NON-OPERATING</u>						
GROUND, FIXED	*	*	1.42	3.26	-	-
<u>OPERATING</u>						
SATELLITE	-	-	-	-		
GROUND	7	5.827	1200.	2020.		
GROUND, MOBILE	15	8.979	1670.	2380.		
AIRBORNE	15	.564	26600.	37800.		
MISSILE	-	-	-	-		
SHIPBOARD	-	-	-	-		
SUBMARINE	-	-	-	-		
HELICOPTER	2	.077	26000	69100.		

ENVIRONMENTAL FACTORS

NON-OPERATING	OPERATING								
	G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
	1.0	-	840	1200	19000	-	-	-	18000

\*See Filter, Nonelectric, General

PART CATEGORY: FILTER, NONELECTRIC

DESCRIPTION: LIQUID

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			RANGE	
			BEST ESTIMATE	90% CONFIDENCE	LOW	HIGH	
<u>NON-OPERATING</u>							
GROUND, FIXED	*	*	<1.42	3.26	-	-	
<u>OPERATING</u>							
SATELLITE	-	-	-	-	-	-	
GROUND	36	12.054	2990.	3720.			
GROUND, MOBILE	716	62.926	11400.	11900.			
AIRBORNE	225	8.603	26200.	28526.			
MISSILE	-	-	-	-			
SHIPBOARD	-	-	-	-			
SUBMARINE	-	-	-	-			
HELICOPTER	36	.727	49500.	61700.			

ENVIRONMENTAL FACTORS

NON-OPERATING	OPERATING								
	G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
	1.0	-	2100	8000	18000	-	-	-	35000

\*See Filter, Nonelectric, General

PART CATEGORY: FITTINGS

DESCRIPTION: GENERAL

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			RANGE
			BEST ESTIMATE	90% CONFIDENCE	LOW	
			HIGH			
<u>NON-OPERATING</u>						
GROUND, FIXED	0	.662	1510.	3496.	-	-
<u>OPERATING</u>						
SATELLITE						
GROUND	0	.829	1105.	-	-	-
GROUND, MOBILE						
AIRBORNE						
MISSILE						
SHIPBOARD						
SUBMARINE						
HELICOPTER	43	1.45	29655.	38241.		

ENVIRONMENTAL FACTORS

NON-OPERATING

OPERATING

G<sub>F</sub>  
1.0

<u>S<sub>A</sub></u>	<u>G</u>	<u>G<sub>M</sub></u>	<u>A</u>	<u>M</u>	<u>S<sub>H</sub></u>	<u>S<sub>II</sub></u>	<u>H</u>
	.73						19

PART CATEGORY: FITTINGS

DESCRIPTION: QUICK, DISCONNECT  
LIQUID, GROUND

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
<u>NON-OPERATING</u>						
GROUND, FIXED	*	*	1510.	3496.	-	-
<u>OPERATING</u>						
SATELLITE						
GROUND						
GROUND, MOBILE	7	.537	13035.	24488.		
AIRBORNE	669	.709	945183.	1005639		
MISSILE						
SHIPBOARD						
SUBMARINE						
HELICOPTER	3	10.	300000.	775000.		

ENVIRONMENTAL FACTORS

NON-OPERATING

OPERATING

G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
1.0			3.6	624				198

\*See Fittings, General

**PART CATEGORY: FITTINGS**

**DESCRIPTION: QUICK, DISCONNECT  
LIQUID/SUR**

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN ITS			RANGE	
			BEST ESTIMATE	90% CONFIDENCE	LOW	HIGH	
<b><u>NON-OPERATING</u></b>							
GROUND, FIXED	4	8.012	499.0	485.	170	1142	
<b><u>OPERATING</u></b>							
SATELLITE							
GROUND							
GROUND, MOBILE	7	.53713035.	24488.	-	-	-	
AIRBORNE	669	.709943583.	1005639	-	-	-	
MISSILE							
SHIPBOARD							
SUBMARINE							
HELICOPTER	3	.010300000.	795000.	-	-	-	

**ENVIRONMENTAL FACTORS**

NON-OPERATING	OPERATING								
	G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
	1.0			26	1890				691

PART CATEGORY: FITTINGS

DESCRIPTION: HYDRAULIC, GROUND

ENVIRONMENT	FAIL- URES	PART HOURS ( $10^6$ )	FAILURE RATE IN FITS			RANGE
			BEST ESTIMATE	90% CONFI- DENCE	LOW	
<u>NON-OPERATING</u>						
GROUND, FIXED	0	.330	2776.0	7003.	..	-
<u>OPERATING</u>						
SATELLITE						
GROUND						
GROUND, MOBILE						
AIRBORNE						
MISSILE						
SHIPBOARD						
SUBMARINE						
HELICOPTER	32	8.21	3898.	5238.		

ENVIRONMENTAL FACTORS								
NON-OPERATING	OPERATING							
$G_F$	$S_A$	G	$G_M$	A	M	$S_H$	$S_U$	H
1.0								1.4

PART CATEGORY: FITTINGS

DESCRIPTION: SWIVEL, HYDRAULIC

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			RANGE
			BEST ESTIMATE	90% CONFIDENCE	LOW	
			HIGH			
<u>NON-OPERATING</u> GROUND, FIXED						
<u>OPERATING</u> SATELLITE GROUND GROUND, MOBILE AIRBORNE MISSILE SHIPBOARD SUBMARINE HELICOPTER	3	.098	30612.	79082.	..	..

ENVIRONMENTAL FACTORS

NON-OPERATING

OPERATING

G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
1.0								

PART CATEGORY: GASKETS & SEALS  
 DESCRIPTION: GASKETS, GENERAL

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
<u>NON-OPERATING</u>						
GROUND, FIXED	-	-	11.	-	-	-
<u>OPERATING</u>						
SATELLITE	-	-	-	-	-	-
GROUND	9	6.282	1430.	2260.		
GROUND, MOBILE	85	52.67	1610.	1860.		
AIRBORNE	-	-	-	-		
MISSILE	-	-	-	-		
SHIPBOARD	11	2.92	3770.	5700.		
SUBMARINE	-	-	-	-		
HELICOPTER	35	1.72	20300	25500.		

ENVIRONMENTAL FACTORS									
NON-OPERATING			OPERATING						
G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H	
1.0	-	130	150	-	-	340	-	1800	

PART CATEGORY: GASKETS & SEALS

DESCRIPTION: O-Rings

ENVIRONMENT	FAIL- URES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			RANGE
			BEST ESTIMATE	90% CONFI- DENCE	LOW	
<u>NON-OPERATING</u>						
GROUND, FIXED	-	-	78.	-	-	-
<u>OPERATING</u>						
SATELLITE	-	-	-	-	-	-
GROUND	-	-	-	-	-	-
GROUND, MOBILE	9	7.613	1180.	1870.		
AIRBORNE	44	18.431	2390.	2920.		
MISSILE	-	-	-	-	-	-
SHIPBOARD	-	-	-	-	-	-
SUBMARINE	-	-	-	-	-	-
HELICOPTER	7	.025	280000.	472000.		

#### ENVIRONMENTAL FACTORS

NON-OPERATING	OPERATING								
	G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
	1.0	-	-	15	31	-	-	-	3600

PART CATEGORY: GASKETS & SEALS

DESCRIPTION: PACKING

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			RANGE	LOW	HIGH
			BEST ESTIMATE	90% CONFIDENCE				
<u>NON-OPERATING</u>								
GROUND, FIXED	-	-	1.5	-	-	-	-	-
<u>OPERATING</u>								
SATELLITE	-	-	-	-	-	-	-	-
GROUND	9	2.549	3530.	5580				
GROUND, MOBILE	2	7.31	273.	728				
AIRBORNE	17	11.244	1510	2100				
MISSILE	-	-	-	-				
SHIPBOARD	-	-	-	-				
SUBMARINE	-	-	-	-				
HELICOPTER	545	93.047	5860.	6190				

#### ENVIRONMENTAL FACTORS

NON-OPERATING

OPERATING

G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
1.0	-	2300	180	1000	-	-	-	3900

PART CATEGORY: GASKETS & SEALS

DESCRIPTION: SEALS, GENERAL

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
					LOW	HIGH
<u>NON-OPERATING</u>						
GROUND, FIXED	1	100.2	9.98	38.8	-	-
<u>OPERATING</u>						
SATELLITE	-	-	-	-	-	-
GROUND	-	-	-	-	-	-
GROUND, MOBILE	171	78.496	2180.	2410.		
AERBORNE	9296	331.11	28100.	28400.		
MISSILE	-	-	-	-	-	-
SHIPBOARD	-	-	-	-	-	-
SUBMARINE	-	-	-	-	-	-
HELICOPTER	339	9.581	35400.	38000.		

ENVIRONMENTAL FACTORS									
NON-OPERATING			OPERATING						
G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H	
1.0	-	-	220	2800	-	-	-	3500	

PART CATEGORY: GASKETS & SEALS

DESCRIPTION: SEALS, MAGNETIC

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
					LOW	HIGH
<u>NON-OPERATING</u>						
GROUND, FIXED	-	-	23	-	-	-
<u>OPERATING</u>						
SATELLITE	-	-	-	-	-	-
GROUND	-	-	-	-	-	-
GROUND, MOBILE	-	-	-	-	-	-
AIRBORNE	92	.153	601000	690000	-	-
MISSILE	-	-	-	-	-	-
SHIPBOARD	-	-	-	-	-	-
SUBMARINE	-	-	-	-	-	-
HELICOPTER	-	-	-	-	-	-

ENVIRONMENTAL FACTORS									
NON-OPERATING			OPERATING						
G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H	
1.0	-	-	-	2600	-	-	-	-	

PART CATEGORY:	GASKETS & SEALS
DESCRIPTION:	SEALS, PRESSURE

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			RANGE	
			BEST ESTIMATE	90% CONFIDENCE			
			LOW	HIGH			
<u>NON-OPERATING</u>							
GROUND, FIXED	*	*	9.98	38.8	-	-	-
<u>OPERATING</u>							
SATELLITE	-	-	-	-	-	-	-
GROUND	-	-	-	-	-	-	-
GROUND, MOBILE	-	-	-	-	-	-	-
AIRBORNE	1558	17.893	87100.	90000.			
MISSILE	-	-	-	-	-	-	-
SHIPBOARD	-	-	-	-	-	-	-
SUBMARINE	-	-	-	-	-	-	-
HELICOPTER	-	-	-	-	-	-	-

ENVIRONMENTAL FACTORS									
NON-OPERATING			OPERATING						
G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H	
1.0	-	-	-	8700	-	-	-	-	

\*See Gaskets & Seals, Seals, General

PART CATEGORY: HOSES

DESCRIPTION: FLEXIBLE METAL  
SUB

ENVIRONMENT	FAIL- URES	PART HOURS ( $10^6$ )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFI- DENCE	RANGE	
			LOW	HIGH		
<u>NON-OPERATING</u>						
GROUND, FIXED	7	4.009	1746.0	-	819	3280
<u>OPERATING</u>						
SATELLITE						
GROUND						
GROUND, MOBILE	16	66.76	240.	364.		
AIRBORNE	30	.259	115830.	157143.		
MISSILE						
SHIPBOARD						
SUBMARINE						
HELICOPTER	208	5.194	40046.	44897.		

ENVIRONMENTAL FACTORS

NON-OPERATING

OPERATING

G<sub>F</sub>

1.0

S<sub>A</sub>

G

G<sub>M</sub>

A

M

S<sub>H</sub>

S<sub>U</sub>

H

PART CATEGORY: PUMP  
 DESCRIPTION: GENERAL

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
					LOW	HIGH
<u>NON-OPERATING</u>						
GROUNDS, FIXED	953	2360.1	406	423	200	1500
<u>OPERATING</u>						
SATELLITE	-	-	-	-	-	-
GROUND	22	5.215	4220	5610		
GROUND, MOBILE	-	-	-	-		
AIRBORNE	20918	192.2	109000	110000		
MISSILE	-	-	-	-		
SHIPBOARD	19	.436	43600	59400		
SUBMARINE	12	.467	25700	38200		
HELICOPTER	520	1.5845	328000	347000		

ENVIRONMENTAL FACTORS									
NON-OPERATING			OPERATING						
G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H	
1.0	-	10	-	270	-	110	63	810	

PART CATEGORY:	PUMP
DESCRIPTION:	FIXED DISPLACEMENT, GENERAL

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
<u>NON-OPERATING</u>						
GROUND, FIXED	327	360.05	380	408	200	582
<u>OPERATING</u>						
SATELLITE						
GROUND						
GROUND, MOBILE						
AIRBORNE						
MISSILE						
SHIPBOARD						
SUBMARINE						
HELICOPTER						

ENVIRONMENTAL FACTORS								
NON-OPERATING			OPERATING					
G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
1.0								

PART CATEGORY: PUMP, FIXED DISPLACEMENT

DESCRIPTION: GEAR

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
					LOW	HIGH
NON-OPERATING						
GROUND, FIXED	167	380.	439	486	300	582
OPERATING						
SATELLITE						
GROUND						
GROUND, MOBILE						
AIRBORNE						
MISSILE						
SHIPBOARD						
SUBMARINE						
HELICOPTER						

ENVIRONMENTAL FACTORS

NON-OPERATING

OPERATING

G<sub>F</sub>

1.0

S<sub>A</sub>

G

G<sub>M</sub>

A

M

S<sub>H</sub>

S<sub>U</sub>

H

PART CATEGORY:	PUMP, FIXED DISPLACEMENT	
DESCRIPTION:	PISTON	

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
<u>NON-OPERATING</u>						
GROUND, FIXED	112	320	350	486	200	500
<u>OPERATING</u>						
SATELLITE						
GROUND						
GROUND, MOBILE						
AIRBORNE						
MISSILE						
SHIPBOARD						
SUBMARINE						
HELICOPTER						

ENVIRONMENTAL FACTORS								
NON-OPERATING			OPERATING					
G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
1.0								

PART CATEGORY: PUMP, FIXED DISPLACEMENT

DESCRIPTION: VANE

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			RANGE	
			BEST ESTIMATE	90% CONFIDENCE	LOW		
			-	-	-	-	-
<u>NON-OPERATING</u>							
GROUND, FIXED	48	160	300	363	-	-	-
<u>OPERATING</u>							
SATELLITE							
GROUND							
GROUND, MOBILE							
AIRBORNE							
MISSILE							
SHIPBOARD							
SUBMARINE							
HELICOPTER							

ENVIRONMENTAL FACTORS								
NON-OPERATING			OPERATING					
G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
1.0								

PART CATEGORY: PUMPS, VARIABLE DISPLACEMENT

DESCRIPTION: GENERAL

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
					LOW	HIGH
<u>NON-OPERATING</u>						
GROUND, FIXED	152	320	475	528	200	700
<u>OPERATING</u>						
SATELLITE						
GROUND						
GROUND, MOBILE						
AIRBORNE						
MISSILE						
SHIPBOARD						
SUBMARINE						
HELICOPTER						

ENVIRONMENTAL FACTORS								
NON-OPERATING			OPERATING					
G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
1.0								

PART CATEGORY:	PUMPS, VARIABLE DISPLACEMENT				
DESCRIPTION:	PISTON				

ENVIRONMENT	FAIL- URES	PART HOURS ( $10^6$ )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFI- DENCE	RANGE	
					LOW	HIGH
<u>NON-OPERATING</u>						
GROUND, FIXED	87	160	544	626	200	700
<u>OPERATING</u>						
SATELLITE						
GROUND						
GROUND, MOBILE						
AIRBORNE						
MISSILE						
SHIPBOARD						
SUBMARINE						
HELICOPTER						

ENVIRONMENTAL FACTORS									
NON-OPERATING		OPERATING							
$G_F$		$S_A$	G	$G_M$	A	M	$S_H$	$S_U$	H
	1.0								

PART CATEGORY: PUMPS, VARIABLE DISPLACEMENT

DESCRIPTION: VANE

ENVIRONMENT	FAILURES	PART HOURS ( $10^6$ )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
<u>NON-OPERATING</u>						
GROUND, FIXED	65	160	406	477	200	500
<u>OPERATING</u>						
SATELLITE						
GROUND						
GROUND, MOBILE						
AIRBORNE						
MISSILE						
SHIPBOARD						
SUBMARINE						
HELICOPTER						

ENVIRONMENTAL FACTORS								
NON-OPERATING			OPERATING					
G <sub>F</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H	
1.0								

PART CATEGORY: PUMP

DESCRIPTION: CENTRIFUGAL

ENVIRONMENT	FAIL- URES	PART HOURS ( $10^6$ )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFI- DENCE	RANGE	
					LOW	HIGH
<u>NON-OPERATING</u>						
GROUND, FIXED	32	160	200	253	-	-
<u>OPERATING</u>						
SATELLITE	-	-	-	-	-	-
GROUND	15	1.244	12100	17100	-	-
GROUND, MOBILE	-	-	-	-	-	-
AIRBORNE	-	-	-	-	-	-
MISSILE	-	-	-	-	-	-
SHIPBOARD	254	.852	298000	323000	-	-
SUBMARINE	-	-	-	-	-	-
HELICOPTER	-	-	-	-	-	-

#### ENVIRONMENTAL FACTORS

##### NON-OPERATING

##### OPERATING

G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
1.0	-	60	-	-	-	1500	-	-

PART CATEGORY: PUMP

DESCRIPTION: FUEL (General)

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			RANGE	
			REST ESTIMATE	90% CONFIDENCE	LOW	HIGH	
<u>NON-OPERATING</u>							
GROUND, FIXED	0	8.07	<124	286	-	-	
<u>OPERATING</u>							
SATELLITE	-	-	-	-			
GROUND	1	.041	24400.	94900			
GROUND, MOBILE	191	8.261	23100.	25400			
AIRBORNE	554	12.289	45100.	47600			
MISSILE	-	-	-	-			
SHIPBOARD	-	-	-	-			
SUBMARINE	-	-	-	-			
HELICOPTER	90	.566	159000	183000			

ENVIRONMENTAL FACTORS

NON-OPERATING	OPERATING								
	G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
	1.0	-	200	190	360	-	-	-	1300

PART CATEGORY: PUMP  
 DESCRIPTION: FUEL BOOST

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			RANGE	
			BEST ESTIMATE	90% CONFIDENCE	LOW	HIGH	
<b>NON-OPERATING</b>							
GROUND, FIXED	*	*	<124	286	-	-	
<b>OPERATING</b>							
SATELLITE	-	-	-	-	-	-	
GROUND	30	.17	176000	225000			
GROUND, MOBILE	-	-	-	-	-	-	
AIRBORNE	1354	19.602	69100	71500			
MISSILE	-	-	-	-	-	-	
SHIPBOARD	-	-	-	-	-	-	
SUBMARINE	-	-	-	-	-	-	
HELICOPTER	41	.205	200000	246000			

ENVIRONMENTAL FACTORS									
NON-OPERATING			OPERATING						
G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H	
1.0	-	1400	-	560	-	-	-	1600	

\*See Pump, Fuel, General

PART CATEGORY: PUMP

DESCRIPTION: FUEL JETTISON

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			RANGE
			BEST ESTIMATE	90% CONFIDENCE	LOW	
			HIGH			
NON-OPERATING						
GROUND, FIXED	*	*	<124	286	-	-
OPERATING						
SATELLITE	-	-	-	-	-	-
GROUND	-	-	-	-	-	-
GROUND, MOBILE	-	-	-	-	-	-
AIRBORNE	6	.462	13000	28800	-	-
MISSILE	-	-	-	-	-	-
SEIPBOARD	-	-	-	-	-	-
SUBMARINE	-	-	-	-	-	-
HELICOPTER	-	-	-	-	-	-

ENVIRONMENTAL FACTORS									
NON-OPERATING			OPERATING						
G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H	
1.0	-	-	-	100	-	-	-	-	-

\*See Pump, Fuel, General

PART CATEGORY: PUMP

DESCRIPTION: FUEL TRANSFER, HYDRAULIC DRIVEN

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			RANGE	
			BEST ESTIMATE	90% CONFIDENCE	LOW		
<u>NON-OPERATING</u>							
GROUND, FIXED	*	*	<124	286	-	-	-
<u>OPERATING</u>							
SATELLITE	-	-	-	-	-	-	-
GROUND	-	-	-	-	-	-	-
GROUND, MOBILE	-	-	-	-	-	-	-
AIRBORNE	231	1.228	188000	205000	-	-	-
MISSILE	-	-	-	-	-	-	-
SHIPBOARD	-	-	-	-	-	-	-
SUBMARINE	-	-	-	-	-	-	-
HELICOPTER	-	-	-	-	-	-	-

ENVIRONMENTAL FACTORS

NON-OPERATING

OPERATING

G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
1.0	-	-	-	1500	-	-	-	-

\*See Pump, Fuel, General

P RT CATEGORY: PUMP, HYDRAULIC

DESCRIPTION: GENERAL

ENVIRONMENT	FAIL- URES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFI- DENCE	RANGE	
			LOW	HIGH		
<b>NON-OPERATING</b>						
GROUND, FIXED	3	31.48	95.3	212	-	-
<b>OPERATING</b>						
SATELLITE	-	-	-	-		
GROUND	5	2.985	1680	3130		
GROUND, MOBILE	1442	21.514	67000	69300		
AIRBORNE	8034	17.526	458000	465000		
MISSILE	-	-	-	-		
SHIPBOARD	-	-	-	-		
SUBMARINE	-	-	-	-		
HELICOPTER	208	.569	366000	400000		

ENVIRONMENTAL FACTORS

NON- OPERATING

OPERATING

G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
1.0	-	18	700	4800	-	-	-	3800

PART CATEGORY: PUMP, HYDRAULIC

DESCRIPTION: MANUAL

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
<u>NON-OPERATING</u>						
GROUND, FIXED	*	*	95.3	212	-	-
<u>OPERATING</u>						
SATELLITE	-	-	-	-		
GROUND	-	-	-	-		
GROUND, MOBILE	-	-	-	-		
AIRBORNE	1	.435	2300.	8940		
MISSILE	-	-	-	-		
SHIPBOARD	-	-	-	-		
SUBMARINE	-	-	-	-		
HELICOPTER	-	-	-	-		

ENVIRONMENTAL FACTORS

NON-OPERATING	OPERATING								
	G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
	1.0	-	-	-	24	-	-	-	-

\*See Pump, Hydraulic, General

PART CATEGORY: PUMP, HYDRAULIC  
 DESCRIPTION: VARIABLE DELIVERY

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
<u>NON-OPERATING</u>						
GROUND, FIXED	*	*	95.3	212	-	-
<u>OPERATING</u>						
SATELLITE	-	-	-	-		
GROUND	-	-	-	-		
GROUND, MOBILE	-	-	-	-		
AIRBORNE	12	.683	17600.	26100		
MISSILE	-	-	-	-		
SHIPBOARD	-	-	-	-		
SUBMARINE	-	-	-	-		
HELICOPTER	70	.421	166000	195000		

ENVIRONMENTAL FACTORS									
NON-OPERATING			OPERATING						
G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H	
1.0	-	-	-	180	-	-	-	1700	

PART CATEGORY:	PUMP
DESCRIPTION:	IMPELLER

ENVIRONMENT	FAIL- URES	PART HOURS ( $10^6$ )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFI- DENCE	RANGE	
			LOW	HIGH		
<u>NON-OPERATING</u>						
GROUND, FIXED	*	*	406	423	200	1500
<u>OPERATING</u>						
SATELLITE	-	-	-	-	-	-
GROUND	0	.526	<1900	4390	-	-
GROUND, MOBILE	-	-	-	-	-	-
AIRBORNE	-	-	-	-	-	-
MISSILE	-	-	-	-	-	-
SHIPBOARD	-	-	-	-	-	-
SUBMARINE	-	-	-	-	-	-
HELICOPTER	-	-	-	-	-	-

ENVIRONMENTAL FACTORS									
NON-OPERATING			OPERATING						
G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H	
1.0	-	5	-	-	-	-	-	-	-

\*See Pump, General

PART CATEGORY: PUMP  
 DESCRIPTION: OIL

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			RANGE	
			BEST ESTIMATE	90% CONFIDENCE	LOW	HIGH	
<u>NON-OPERATING</u>							
GROUND, FIXED	*	*	406	423	200	1500	
<u>OPERATING</u>							
SATELLITE	-	-	-	-	-	-	
GROUND	-	-	-	-	-	-	
GROUND, MOBILE	-	-	-	-	-	-	
AIRBORNE	33	555	59500	75100			
MISSILE	-	-	-	-	-	-	
SHIPBOARD	-	-	-	-	-	-	
SUBMARINE	-	-	-	-	-	-	
HELICOPTER	-	-	-	-	-	-	

ENVIRONMENTAL FACTORS									
NON-OPERATING			OPERATING						
G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H	
1.0	-	-	-	-	150	-	-	-	-

\*See Pump, General

PART CATEGORY: REGULATOR

DESCRIPTION: GENERAL

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
					LOW	HIGH
<u>NON-OPERATING</u>						
GROUND, FIXED	1	5.777	173	674	-	1330
<u>OPERATING</u>						
SATELLITE	-	-	-	-		
GROUND	-	-	-	-		
GROUND, MOBILE	-	-	-	-		
AIRBORNE	365	3.382	108000	115000		
MISSILE	-	-	-	-		
SHIPBOARD	-	-	-	-		
SUBMARINE	-	-	-	-		
HELICOPTER	-	-	-	-		

ENVIRONMENTAL FACTORS

<u>NON-OPERATING</u>	<u>OPERATING</u>								
	<u>G<sub>F</sub></u>	<u>S<sub>A</sub></u>	<u>G</u>	<u>G<sub>M</sub></u>	<u>A</u>	<u>M</u>	<u>S<sub>H</sub></u>	<u>S<sub>U</sub></u>	<u>H</u>
	1.0	-	-	-	620	-	-	-	-

PART CATEGORY: REGULATOR

DESCRIPTION: BELL MOUTH CONTROLLER, JET ENGINE

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
<u>NON-OPERATING</u>						
GROUND, FIXED	*	*	173	674	-	1330
<u>OPERATING</u>						
SATELLITE	-	-	-	-		
GROUND	-	-	-	-		
GROUND, MOBILE	-	-	-	-		
AIRBORNE	106	1.109	95600	109000		
MISSILE	-	-	-	-		
SHIPBOARD	-	-	-	-		
SUBMARINE	-	-	-	-		
HELICOPTER	-	-	-	-		

ENVIRONMENTAL FACTORS									
NON-OPERATING			OPERATING						
G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H	
1.0	-	-	-	550	-	-	-	-	

\* See Regulator, General

PART CATEGORY: REGULATOR

DESCRIPTION: FLUID TENSION

ENVIRONMENT	FAIL- URES	PART HOURS ( $10^6$ )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFID- ENCE	RANGE	
					LOW	HIGH
<b>NON-OPERATING</b>						
GROUND, FIXED	*	*	173	574	-	1330
<b>OPERATING</b>						
SATELLITE	-	-	-	-	-	-
GROUND	-	-	-	-	-	-
GROUND, MOBILE	-	-	-	-	-	-
AIRBORNE	28	5.363	5220	6710	-	-
MISSILE	-	-	-	-	-	-
SHIPBOARD	-	-	-	-	-	-
SUBMARINE	-	-	-	-	-	-
HELICOPTER	-	-	-	-	-	-

ENVIRONMENTAL FACTORS

NON-OPERATING	OPERATING								
	G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
	1.0	-	-	-	30	-	-	-	-

\*See Regulator, General

PART CATEGORY:	REGULATOR
DESCRIPTION:	FUEL

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
<u>NON-OPERATING</u>						
GROUND, FIXED	*	*	173	674	-	1330
<u>OPERATING</u>						
SATELLITE	-	-	-	-		
GROUND	-	-	-	-		
GROUND, MOBILE	-	-	-	-		
AIRBORNE	1031	5.766	179000	186000		
MISSILE	-	-	-	-		
SHIPBOARD	-	-	-	-		
SUBMARINE	-	-	-	-		
HELICOPTER	41	.301	136000	168000		

ENVIRONMENTAL FACTORS									
NON-OPERATING			OPERATING						
G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H	
1.0	-	-	-	1000	-	-	-	-	790

\*See Regulator, General

PART CATEGORY: REGULATOR

DESCRIPTION: PRESSURE

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			RANGE	
			BEST ESTIMATE	90% CONFIDENCE			
			LOW	HIGH			
<u>NON-OPERATING</u>							
GROUND, FIXED	1	.753	1330	5170	-	-	-
<u>OPERATING</u>							
SATELLITE	1	.35	2860	11100			
GROUND	3	.28	10700	23800			
GROUND, MOBILE	19	8.449	2250	3070			
AIRBORNE	1631	13.047	125000	129000			
MISSILE	-	-	-	-			
SHIPBOARD	-	-	-	-			
SUBMARINE	-	-	-	-			
HELICOPTER	-	-	-	-			

ENVIRONMENTAL FACTORS

NON-OPERATING

OPERATING

G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
1.0	2	8	2	94	-	-	-	-

PART CATEGORY: REGULATORS

DESCRIPTION: TEMPERATURE

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
					LOW	HIGH
<u>NON-OPERATING</u>						
GROUND, FIXED	0	5.024	<199	460	-	-
<u>OPERATING</u>						
SATELLITE	1	.287	3480	13600		
GROUND	49	11.296	4340	5240		
GROUND, MOBILE	27	1.553	17400	22500		
AIRBORNE	3663	24.783	148000	151000		
MISSILE	-	-	-	-		
SHIPBOARD	-	-	-	-		
SUBMARINE	-	-	-	-		
HELICOPTER	-	-	-	-		

ENVIRONMENTAL FACTORS

NON-OPERATING

OPERATING

G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
1.0	17	22	87	740	-	-	-	-

PART CATEGORY: VALVES  
 DESCRIPTION: GENERAL

ENVIRONMENT	FAIL- URES	PART HOURS ( $10^6$ )	FAILURE RATE IN FITS				
			BEST ESTIMATE	90% CONFI- DENCE	RANGE		
			LOW	HIGH			
<u>NON-OPERATING</u>							
GROUND, FIXED	30	2424.3	12.4	15.8	-	32.3	
<u>OPERATING</u>							
SATELLITE	-	-	-	-			
GROUND	171	11.5	14900.	16400			
GROUND, MOBILE	1	.846	1180.	4600			
AIRBORNE	14244	218.2	65300.	66000			
MISSILE	30	.22	136000.	174000			
SHIPBOARD	2	.0054	370000.	985000			
SUBMARINE	-	-	-	-			
HELICOPTER	223	2.257	98800.	108000			

ENVIRONMENTAL FACTORS									
NON-OPERATING			OPERATING						
G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H	
1.0	-	1200	95	5300	11000	30000	-	8000	

PART CATEGORY: VALVES, GENERAL

DESCRIPTION: BALL

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
					LOW	HIGH
<b>NON-OPERATING</b>						
GROUND, FIXED	*	*	12.4	15.8	-	32.3
<b>OPERATING</b>						
SATELLITE	-	-	-	-	-	-
GROUND	0	4.254	<235.	543.	-	-
GROUND, MOBILE	5	3.469	1440.	2690.	-	-
AIRBORNE	-	-	-	-	-	-
MISSILE	-	-	-	-	-	-
SHIPBOARD	-	-	-	-	-	-
SUBMARINE	-	-	-	-	-	-
HELICOPTER	-	-	-	-	-	-

ENVIRONMENTAL FACTORS

NON-OPERATING	OPERATING								
	G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
	1.0	-	19	120	-	-	-	-	-

\*See Valves, General

PART CATEGORY: VALVES, GENERAL

DESCRIPTION: BUTTERFLY

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
					LOW	HIGH
<u>NON-OPERATING</u>						
GROUND, FIXED	*	*	12.4	15.8	-	32.3
<u>OPERATING</u>						
SATELLITE	-	-	-	-	-	
GROUND	1	6.013	166.	647	-	
GROUND, MOBILE	-	-	-	-	-	
AIRBORNE	0	.01	<100	231	-	
MISSILE	-	-	-	-	-	
SHIPBOARD	-	-	-	-	-	
SUBMARINE	-	-	-	-	-	
HELICOPTER	-	-	-	-	-	

ENVIRONMENTAL FACTORS									
NON-OPERATING			OPERATING						
G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H	
1.0	-	13	-	8	-	-	-	-	-

\*See Valves, General

PART CATEGORY: VALVES, GENERAL

DESCRIPTION: CHECK

ENVIRONMENT	FAILURES	PART HOURS ( $10^6$ )	FAILURE RATE IN FITS			RANGE	
			BEST ESTIMATE	90% CONFIDENCE	LOW	HIGH	
<b>NON-OPERATING</b>							
GROUND, FIXED	*	*	12.4	15.8	-	32.3	
<b>OPERATING</b>							
SATELLITE	-	-	-	-	-		
GROUND	3	1.659	3010.	5630.			
GROUND, MOBILE	-	-	-	-	-		
AIRBORNE	2356	84.24	28000.	28700.			
MISSILE	-	-	-	-	-		
SHIPBOARD	-	-	-	-	-		
SUBMARINE	-	-	-	-	-		
HELICOPTER	6	0.597	10000.	177000.			

ENVIRONMENTAL FACTORS									
NON-OPERATING		OPERATING							
G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H	
1.0	-	240	-	2300	-	-	-	-	810

\*See Valves, General

PART CATEGORY: VALVES, GENERAL

DESCRIPTION: CONTROL

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			RANGE
			BEST ESTIMATE	90% CONFIDENCE	LOW	
<u>NON-OPERATING</u>						
GROUND, FIXED	*	*	12.4	15.8	-	32.3
<u>OPERATING</u>						
SATELLITE	-	-	-	-	-	
GROUND	-	-	-	-	-	
GROUND, MOBILE	-	-	-	-	-	
AIRBORNE	3228	30.071	107000.	110000	-	
MISSILE	-	-	-	-	-	
SHIPBOARD	-	-	-	-	-	
SUBMARINE	-	-	-	-	-	
HELICOPTER	-	-	-	-	-	

ENVIRONMENTAL FACTORS

NON-OPERATING	OPERATING								
	G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
	1.0	-	-	-	8600	-	-	-	-

\*See Valves, General

PART CATEGORY: VALVES, GENERAL

DESCRIPTION: GLOBE

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			RANGE	
			BEST ESTIMATE	90% CONFIDENCE	LOW	HIGH	
<b>NON-OPERATING</b>							
GROUND, FIXED	*	*	12.4	15.8	-	32.3	
<b>OPERATING</b>							
SATELLITE	-	-	-	-	-		
GROUND	0	4.955	<202.	466.			
GROUND, MOBILE	-	-	-	-	-		
AIRBORNE	-	-	-	-	-		
MISSILE	-	-	-	-	-		
SHIPBOARD	-	-	-	-	-		
SUBMARINE	-	-	-	-	-		
HELICOPTER	-	-	-	-	-		

ENVIRONMENTAL FACTORS

NON-OPERATING	OPERATING								
	G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
	1.0	-	16	-	-	-	-	-	-

\*See Valves, General

PART CATEGORY: VALVES, GENERAL

DESCRIPTION: RELIEF

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
					LOW	HIGH
<u>NON-OPERATING</u>						
GROUND, FIXED	*	*	12.4	15.8	-	32.3
<u>OPERATING</u>						
SATELLITE	-	-	-	-		
GROUND	17	11.23	1510.	2100.		
GROUND, MOBILE	2	.228	8770.	23300.		
AIRBORNE	897	29.26	30700.	32000.		
MISSILE	-	-	-	-		
SHIPBOARD	-	-	-	-		
SUBMARINE	-	-	-	-		
HELICOPTER	90	0.607	148000.	170000.		

ENVIRONMENTAL FACTORS

NON-OPERATING	OPERATING								
	G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
	1.0	-	120	710	2500	-	-	-	12000

\*See Valves, General

PART CATEGORY: VALVES, GENERAL

DESCRIPTION: SELECTOR

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			RANGE	
			BEST ESTIMATE	90% CONFIDENCE	LOW	HIGH	
<u>NON-OPERATING</u>							
GROUND, FIXED	*	*	12.4	15.8	-	32.3	
<u>OPERATING</u>							
SATELLITE	-	-	-	-	-		
GROUND	-	-	-	-	-		
GROUND, MOBILE	0	.046	<21700.	50200.			
AIRBORNE	2	.021	95200	253000.			
MISSILE							
SHIPBOARD							
SUBMARINE							
HELICOPTER							

ENVIRONMENTAL FACTORS

NON-OPERATING

OPERATING

G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
1.0	-	-	1700	7700	-	-	-	-

\*See Valves, General

PART CATEGORY: VALVES, GENERAL

DESCRIPTION: SEQUENCE

ENVIRONMENT	FAILURES	PART HOURS ( $10^6$ )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
<u>NON-OPERATING</u>						
GROUND, FIXED	-	-	194.	-	-	-
<u>OPERATING</u>						
SATELLITE						
GROUND						
GROUND, MOBILE						
AIRBORNE						
MISSILE						
SHIPBOARD						
SUBMARINE						
HELICOPTER						

ENVIRONMENTAL FACTORS

NON-OPERATING

OPERATING

G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
1.0								

PART CATEGORY: VALVES, GENERAL

DESCRIPTION: SHUTOFF

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
					LOW	HIGH
<u>NON-OPERATING</u>						
GROUND, FIXED	*	*	12.4	15.8	-	32.3
<u>OPERATING</u>						
SATELLITE	-	-	-	-		
GROUND	-	-	-	-		
GROUND, MOBILE	2	.141	14200.	37700.		
AIRBORNE	4360	46.9	93000.	94800.		
MISSILE	-	-	-	-		
SHIPBOARD	-	-	-	-		
SUBMARINE	-	-	-	-		
HELICOPTER	6	.197	30500	53500		

ENVIRONMENTAL FACTORS

NON-OPERATING	OPERATING								
	G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
	1.0	-	-	1100	7500	-	-	-	2500

\*See Valves, General

PART CATEGORY: VALVES, GENERAL

DESCRIPTION: SOLENOID

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			RANGE
			BEST ESTIMATE	90% CONFIDENCE	LOW	
			HIGH			
<u>NON-OPERATING</u>						
GROUND, FIXED	7	820.65	8.5	14.4	-	-
<u>OPERATING</u>						
SATELLITE	-	-	-	-	-	
GROUND	0	.381	<2620.	6360.		
GROUND, MOBILE	1	.059	16900.	66000.		
AIRBORNE	285	2.824	101000.	109000.		
MISSILE	-	-	-	-	-	
SHIPBOARD	-	-	-	-	-	
SUBMARINE	-	-	-	-	-	
HELICOPTER	40	.321	125000.	153000.		

ENVIRONMENTAL FACTORS

NON-OPERATING	OPERATING								
	G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
	1.0	-	310	2000	12000	-	-	-	15000

PART CATEGORY: VALVES, GENERAL

DESCRIPTION: FREON

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
<u>NON-OPERATING</u>						
GROUND, FIXED	-	-	1380.	-	-	-
<u>OPERATING</u>						
SATELLITE	-	-	-	-	-	-
GROUND	-	-	-	-	-	-
GROUND, MOBILE	-	-	-	-	-	-
AIRBORNE	12	.53	22600.	33600		
MISSILE	-	-	-	-	-	-
SHIPBOARD	-	-	-	-	-	-
SUBMARINE	-	-	-	-	-	-
HELICOPTER	-	-	-	-	-	-

ENVIRONMENTAL FACTORS

NON-OPERATING	OPERATING								
	G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
	1.0	-	-	-	16	-	-	-	-

PART CATEGORY: VALVES, FUEL

DESCRIPTION: GENERAL

ENVIRONMENT	FAIL-URES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			RANGE	
			BEST ESTIMATE	90% CONFIDENCE	LOW	HIGH	
<b>NON-OPERATING</b>							
GROUND, FIXED	1	11.853	84.4	328.	-	-	
<b>OPERATING</b>							
SATELLITE	-	-	-	-	-	-	
GROUND	0	.11	<9090	21000.	-	-	
GROUND, MOBILE	0	.786	<1270	2940.	-	-	
AIRBORNE	142	3.727	38100	42500.	-	-	
MISSILE	-	-	-	-	-	-	
SHIPBOARD	-	-	-	-	-	-	
SUBMARINE	-	-	-	-	-	-	
HELICOPTER	-	-	-	-	-	-	

ENVIRONMENTAL FACTORS									
NON-OPERATING			OPERATING						
G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H	
1.0	-	110	15	450	-	-	-	-	

PART CATEGORY: VALVE, FUEL

DESCRIPTION: CHECK

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
<u>NON-OPERATING</u>						
GROUND, FIXED	1	4.25	235.	916.	-	-
<u>OPERATING</u>						
SATELLITE	-	-	-	-	-	-
GROUND	-	-	-	-	-	-
GROUND, MOBILE	0	.384	<2600.	6010.		
AIRBORNE	18	6.314	2850.	3920.		
MISSILE	-	-	-	-	-	-
SHIPBOARD	-	-	-	-	-	-
SUBMARINE	-	-	-	-	-	-
HELICOPTER	6	.15	40000.	70300.		

ENVIRONMENTAL FACTORS									
NON-OPERATING			OPERATING						
G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H	
1.0	-	-	11	12	-	-	-	170	

PART CATEGORY: VALVE, FUEL

DESCRIPTION: DUMP

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			RANGE	
			BEST ESTIMATE	90% CONFIDENCE			
					LOW	HIGH	
<u>NON-OPERATING</u>							
GROUND, FIXED	*	*	84.4	328.	-	-	
<u>OPERATING</u>							
SATELLITE	-	-	-	-	-	-	
GROUND	-	-	-	-	-	-	
GROUND, MOBILE	-	-	-	-	-	-	
AIRBORNE	4	2.811	1420.	2850.			
MISSILE	-	-	-	-	-	-	
SHIPBOARD	-	-	-	-	-	-	
SUBMARINE	-	-	-	-	-	-	
HELICOPTER	-	-	-	-	-	-	

ENVIRONMENTAL FACTORS

NON-OPERATING	OPERATING								
	G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
	1.0	-	-	-	17	-	-	-	-

\*See Valve, Fuel, General

PART CATEGORY: VALVE, FUEL

DESCRIPTION: FLOAT

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
<u>NON-OPERATING</u>						
GROUND, FIXED	*	*	84.4	328.	-	-
<u>OPERATING</u>						
SATELLITE	-	-	-	-		
GROUND	-	-	-	-		
GROUND, MOBILE	-	-	-	-		
AIRBORNE	803	11.959	67100.	70300.		
MISSILE	-	-	-	-		
SHIPBOARD	-	-	-	-		
SUBMARINE	-	-	-	-		
HELICOPTER	2	.05	40000.	106000.		

#### ENVIRONMENTAL FACTORS

NON-OPERATING	OPERATING								
	G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
	1.0	-	-	-	800	-	-	-	470

\*See Valve, Fuel, General

PART CATEGORY: VALVE, FUEL  
 DESCRIPTION: GATE

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			RANGE	
			BEST ESTIMATE	90% CONFIDENCE			
			LOW	HIGH			
<u>NON-OPERATING</u>							
GROUND, FIXED	*	*	84.4	328.	-	-	-
<u>OPERATING</u>							
SATELLITE	-	-	-	-	-	-	-
GROUND	-	-	-	-	-	-	-
GROUND, MOBILE	-	-	-	-	-	-	-
AIRBORNE	72	1.914	37600.	43900.			
MISSILE	-	-	-	-	-	-	-
SHIPBOARD	-	-	-	-	-	-	-
SUBMARINE	-	-	-	-	-	-	-
HELICOPTER	5	.07	71400.	134000.			

ENVIRONMENTAL FACTORS									
NON-OPERATING		OPERATING							
G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H	
1.0	-	-	-	440	-	-	-	850	

\*See Valve, Fuel, General

PART CATEGORY: VALVE, FUEL

DESCRIPTION: PRESSURE REGULATOR

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
<u>NON-OPERATING</u>						
GROUND, FIXED	-	-	2390.	-	-	-
<u>OPERATING</u>						
SATELLITE	-	-	-	-		
GROUND	-	-	-	-		
GROUND, MOBILE	-	-	-	-		
AIRBORNE	90	1.384	65000.	74700.		
MISSILE	-	-	-	-		
SHIPBOARD	-	-	-	-		
SUBMARINE	-	-	-	-		
HELICOPTER	26	.47	55300.	71900.		

#### ENVIRONMENTAL FACTORS

NON-OPERATING

OPERATING

G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
1.0	-	-	-	27	-	-	-	23

**ENVIRONMENTAL FACTORS**

**Applicability**

		<u>G<sub>B</sub></u>	<u>S<sub>F</sub></u>	<u>G<sub>F</sub></u>	<u>A<sub>I</sub></u>	<u>N<sub>S</sub></u>	<u>G<sub>M</sub></u>	<u>N<sub>U</sub></u>	<u>A<sub>U</sub></u>	<u>M<sub>L</sub></u>
Capacitors, Aluminum Oxide MIL-C-39018	MIL-STD	0.5	0.5	1.0	6.0	6.0	6.0	10.0	15.0	20.0
Aluminum Dry Electrolytic MIL-C-62										

**ENVIRONMENTAL FACTORS**

		<u>G<sub>B</sub></u>	<u>S<sub>F</sub></u>	<u>G<sub>F</sub></u>	<u>A<sub>I</sub></u>	<u>N<sub>S</sub></u>	<u>G<sub>M</sub></u>	<u>N<sub>U</sub></u>	<u>A<sub>U</sub></u>	<u>M<sub>L</sub></u>
Capacitors, Variable, Ceramic MIL-C-81	MIL-STD	0.3	-	1.0	2.0	2.0	2.0	6.0	12.5	17.5

**ENVIRONMENTAL FACTORS**

		<u>G<sub>B</sub></u>	<u>S<sub>F</sub></u>	<u>G<sub>F</sub></u>	<u>A<sub>I</sub></u>	<u>N<sub>S</sub></u>	<u>G<sub>M</sub></u>	<u>N<sub>U</sub></u>	<u>A<sub>U</sub></u>	<u>M<sub>L</sub></u>
Capacitors, Variable, Piston Type MIL-C-14409	MIL-STD	0.3	0.3	1.0	3.0	3.0	3.0	16.7	26.7	40.0

**ENVIRONMENTAL FACTORS**

		<u>G<sub>B</sub></u>	<u>S<sub>F</sub></u>	<u>G<sub>F</sub></u>	<u>A<sub>I</sub></u>	<u>N<sub>S</sub></u>	<u>G<sub>M</sub></u>	<u>N<sub>U</sub></u>	<u>A<sub>U</sub></u>	<u>M<sub>L</sub></u>
All Inductive Devices	L-STD	0.5	0.5	1.0	2.5	2.5	1.5	2.5	3.5	5.0
	Hi-REL	0.5	0.5	1.0	2.5	2.5	1.5	2.5	3.5	5.0

**ENVIRONMENTAL FACTORS**

		<u>G<sub>B</sub></u>	<u>S<sub>F</sub></u>	<u>G<sub>F</sub></u>	<u>A<sub>I</sub></u>	<u>N<sub>S</sub></u>	<u>G<sub>M</sub></u>	<u>N<sub>U</sub></u>	<u>A<sub>U</sub></u>	<u>M<sub>J</sub></u>
Lasers		0.2	0.2	1.0	5.	5.	5.	5.	8.	8.

PART CATEGORY: VALVE, FUEL

DESCRIPTION: SHUT-OFF

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			RANGE	
			BEST ESTIMATE	90% CONFIDENCE			
			LOW	HIGH			
<b>NON-OPERATING</b>							
GROUND, FIXED	*	*	84.4	328.	-	-	
<b>OPERATING</b>							
SATELLITE	-	-	-	-	-	-	
GROUND	-	-	-	-	-	-	
GROUND, MOBILE	-	-	-	-	-	-	
AIRBORNE	36	2.219	16200.	20200.	-	-	
MISSILE	-	-	-	-	-	-	
SHIPBOARD	-	-	-	-	-	-	
SUBMARINE	-	-	-	-	-	-	
HELICOPTER	-	-	-	-	-	-	

ENVIRONMENTAL FACTORS

NON-OPERATING	OPERATING								
	G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
	1.0	-	-	-	190	-	-	-	-

\*See Valve, Fuel, General

PART CATEGORY: VALVE, FUEL

DESCRIPTION: SOLENOID

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			RANGE
			BEST ESTIMATE	90% CONFIDENCE	LOW	
			HIGH			
<u>NON-OPERATING</u>						
GROUND, FIXED	*	*	84.4	328	-	-
<u>OPERATING</u>						
SATELLITE	-	-	-	-	-	
GROUND	54	42.313	1280.	1520		
GROUND, MOBILE	-	-	-	-	-	
AIRBORNE	197	3.416	57700	63300		
MISSILE	-	-	-	-	-	
SHIPBOARD	-	-	-	-	-	
SUBMARINE	-	-	-	-	-	
HELICOPTER	-	-	-	-	-	

ENVIRONMENTAL FACTORS

NON-OPERATING	OPERATING								
	G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
	1.0	-	15	-	680	--	-	-	-

\*See Valve, Fuel, General

PART CATEGORY: VALVE, HYDRAULIC

DESCRIPTION: GENERAL

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			RANGE	
			BEST ESTIMATE	90% CONFIDENCE	LOW	HIGH	
<u>NON-OPERATING</u>							
GROUND, FIXED	4	1419.2	2.82	5.64	1.4	22.9	
<u>OPERATING</u>							
SATELLITE	-	-	-	-	-	-	
GROUND	9	3.316	2710.	4290.	-	-	
GROUND, MOBILE	40	5.432	7360.	9070.	-	-	
AIRBORNE	784	22.47	34900.	36500.	-	-	
MISSILE	-	-	-	-	-	-	
SHIPBOARD	-	-	-	-	-	-	
SUBMARINE	-	-	-	-	-	-	
HELICOPTER	-	-	-	-	-	-	

ENVIRONMENTAL FACTORS

NON-OPERATING	OPERATING								
	G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
	1.0	-	960	2600	12000	-	-	-	-

PART CATEGORY: VALVE, HYDRAULIC

DESCRIPTION: BALL

ENVIRONMENT	FAILURES	PART HOURS ( $10^6$ )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
					LOW	HIGH
<u>NON-OPERATING</u>						
GROUND, FIXED	-	-	374.	-	-	-
<u>OPERATING</u>						
SATELLITE						
GROUND						
GROUND, MOBILE						
AIRBORNE						
MISSILE						
SHIPBOARD						
SUBMARINE						
HELICOPTER						

ENVIRONMENTAL FACTORS

NON-OPERATING

OPERATING

$G_F$	$S_A$	$G$	$G_M$	$A$	$M$	$S_H$	$S_U$	$H$
1.0								

PART CATEGORY: VALVE, HYDRAULIC

DESCRIPTION: BLEEDER

ENVIRONMENT	FAILURES	PART HOURS ( $10^6$ )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
<u>NON-OPERATING</u>						
GROUND, FIXED	0	210.43	<4.75	11.0	-	-
<u>OPERATING</u>						
SATELLITE						
GROUND						
GROUND, MOBILE						
AIRBORNE						
MISSILE						
SHIPBOARD						
SUBMARINE						
HELICOPTER						

ENVIRONMENTAL FACTORS								
NON-OPERATING			OPERATING					
$G_F$	$S_A$	$G$	$G_M$	$A$	$M$	$S_H$	$S_U$	$H$
1.0								

PART CATEGORY: VALVE, HYDRAULIC

DESCRIPTION: CHECK

ENVIRONMENT	FAIL- URES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS				
			BEST ESTIMATE	90% CONFIDENCE	RANGE		
			LOW	HIGH			
<u>NON-OPERATING</u>							
GROUND, FIXED	3	131.02	22.9	50.9	-	761.	
<u>OPERATING</u>							
SATELLITE	-	-	-	-	-		
GROUND	-	-	-	-	-		
GROUND, MOBILE	-	-	-	-	-		
AIRBORNE	362	28.66	12600.	13500.			
MISSILE	-	-	-	-	-		
SHIPBOARD	-	-	-	-	-		
SUBMARINE	-	-	-	-	-		
HELICOPTER	-	-	-	-	-		

ENVIRONMENTAL FACTORS

NON-OPERATING	OPERATING								
	G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	I
	1.0	-	-	-	550	-	-	-	-

PART CATEGORY: VALVE, HYDRAULIC

DESCRIPTION: CONTROL

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
<u>NON-OPERATING</u>						
GROUND, FIXED	0	150.2	<6.66	15.4	-	-
<u>OPERATING</u>						
SATELLITE	-	-	-	-		
GROUND	-	-	-	-		
GROUND, MOBILE	-	-	-	-		
AIRBORNE	296	2.75	108000.	116000.		
MISSILE	-	-	-	-		
SHIPBOARD	-	-	-	-		
SUBMARINE	-	-	-	-		
HELICOPTER	-	-	-	-		

ENVIRONMENTAL FACTORS

NON-OPERATING	OPERATING								
	G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
	1.0	-	-	-	16000	-	-	-	-

PART CATEGORY: VALVE, HYDRAULIC  
 DESCRIPTION: PRESSURE REGULATOR

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
<b>NON-OPERATING</b>						
GROUND, FIXED	*	*	2.82	5.64	1.4	22.9
<b>OPERATING</b>						
SATELLITE	-	-	-	-	-	-
GROUND	-	-	-	-	-	-
GROUND, MOBILE	104	12.357	8420.	9570.	-	-
AIRBORNE	92	3.24	28400.	32600.	-	-
MISSILE	-	-	-	-	-	-
SHIPBOARD	-	-	-	-	-	-
SUBMARINE	-	-	-	-	-	-
HELICOPTER	-	-	-	-	-	-

ENVIRONMENTAL FACTORS									
NON-OPERATING			OPERATING						
G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H	
1.0	-	-	3000	10000	-	-	-	-	-

\*See Valve, Hydraulic, General

PART CATEGORY: VALVE, HYDRAULIC

DESCRIPTION: RELIEF

ENVIRONMENT	FAIL- URES	PART HOURS ( $10^6$ )	FAILURE RATE IN FITS			RANGE	
			BEST ESTIMATE	90% CONFI- DENCE	LOW	HIGH	
<u>NON-OPERATING</u>							
GROUND, FIXED	1	712.8	1.40	3.24	-	-	
<u>OPERATING</u>							
SATELLITE	-	-	-	-	-	-	
GROUND	-	-	-	-	-	-	
GROUND, MOBILE	1	1.152	868.	3400.			
AIRBORNE	194	13.172	14700.	16200.			
MISSILE	-	-	-	-	-	-	
SHIPBOARD	-	-	-	-	-	-	
SUBMARINE	-	-	-	-	-	-	
HELICOPTER	6	.14	42900.	75300.			

#### ENVIRONMENTAL FACTORS

NON-OPERATING	OPERATING								
	G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
	1.0	-	-	620	10000	-	-	-	30000

PART CATEGORY: VALVE, HYDRAULIC

DESCRIPTION: RESTRICTOR

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			RANGE	
			BEST ESTIMATE	90% CONFIDENCE	LOW	HIGH	
<u>NON-OPERATING</u>							
GROUND, FIXED	-	-	5.55	-	-	-	-
<u>OPERATING</u>							
SATELLITE	-	-	-	-	-	-	-
GROUND	-	-	-	-	-	-	-
GROUND, MOBILE	-	-	-	-	-	-	-
AIRBORNE	125	0.452	19400.	21800.			
MISSILE	-	-	-	-	-	-	-
SHIPBOARD	-	-	-	-	-	-	-
SUBMARINE	-	-	-	-	-	-	-
HELICOPTER	-	-	-	-	-	-	-

ENVIRONMENTAL FACTORS									
NON-OPERATING		OPERATING							
G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H	
1.0	-	-	-	3500	-	-	-	-	

PART CATEGORY: VALVE, HYDRAULIC

DESCRIPTION: SEQUENCER

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
<b>NON-OPERATING</b>						
GROUND, FIXED	*	*	2.82	5.64	1.4	22.9
<b>OPERATING</b>						
SATELLITE	-	-	-	-	-	-
GROUND	-	-	-	-	-	-
GROUND, MOBILE	-	-	-	-	-	-
AIRBORNE	61	3.082	19800.	23500.		
MISSILE	-	-	-	-	-	-
SHIPBOARD	-	-	-	-	-	-
SUBMARINE	-	-	-	-	-	-
HELICOP	-	-	-	-	-	-

ENVIRONMENTAL FACTORS									
NON-OPERATING			OPERATING						
G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H	
1.0	-	-	-	7000	-	-	-	-	

\*See Valve, Hydraulic, General

PART CATEGORY: VALVE, HYDRAULIC

DESCRIPTION: SERVO

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			RANGE	
			BEST ESTIMATE	90% CONFIDENCE			
			LOW	HIGH			
<b>NON-OPERATING</b>							
GROUND, FIXED	16	109.67	146.	205.	69.	32300.	
<b>OPERATING</b>							
SATELLITE	-	-	-	-	-		
GROUND	0	.014	<71400.	165000			
GROUND, MOBILE	-	-	-	-	-		
AIRBORNE	485	3.066	158000.	168000			
MISSILE	-	-	-	-	-		
SHIPBOARD	-	-	-	-	-		
SUBMARINE	-	-	-	-	-		
HELICOPTER	12	.038	316000.	469000			

ENVIRONMENTAL FACTORS

NON-OPERATING	OPERATING								
	G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
	1.0	-	490	-	1100	-	-	-	2200

PART CATEGORY: VALVE, HYDRAULIC

DESCRIPTION: SHUTTLE

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			RANGE	
			BEST ESTIMATE	90% CONFIDENCE		LOW	HIGH
<b>NON-OPERATING</b>							
GROUND, FIXED	*	*	146.	205.		69.	32300
<b>OPERATING</b>							
SATELLITE	-	-	-	-		-	
GROUND	-	-	-	-		-	
GROUND, MOBILE	-	-	-	-		-	
AIRBORNE	366	5.783	63300.	67700.			
MISSILE	-	-	-	-		-	
SHIPBOARD	-	-	-	-		-	
SUBMARINE	-	-	-	-		-	
HELICOPTER	-	-	-	-		-	

ENVIRONMENTAL FACTORS								
NON-OPERATING			OPERATING					
G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H
1.0	-	-	-	430	-	-	-	-

\*See Valve, Hydraulic, Servo

PART CATEGORY: VALVE, HYDRAULIC

DESCRIPTION: SHUT-OFF

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
					LOW	HIGH
<b>NON-OPERATING</b>						
GROUND, FIXED	0	214.8	<4.66	10.8	-	-
<b>OPERATING</b>						
SATELLITE	-	-	-	-	-	-
GROUND	-	-	-	-	-	-
GROUND, MOBILE	-	-	-	-	-	-
AIRBORNE	18	3.879	4640.	6380.		
MISSILE	-	-	-	-	-	-
SHIPBOARD	-	-	-	-	-	-
SUBMARINE	-	-	-	-	-	-
HELICOPTER	3	.01	300000.	667000.		

ENVIRONMENTAL FACTORS									
NON-OPERATING			OPERATING						
G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H	
1.0	-	-	-	1000	-	-	-	64000	

PART CATEGORY: VALVE, HYDRAULIC

DESCRIPTION: SOLENOID

ENVIRONMENT	FAIL- URES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS				
			BEST ESTIMATE	90% CONFI- DENCE	RANGE		
			LOW	HIGH			
<u>NON-OPERATING</u>							
GROUND, FIXED	7	820.8	8.53	14.4	-	-	
<u>OPERATING</u>							
SATELLITE	-	-	-	-	-	-	
GROUND	-	-	-	-	-	-	
GROUND, MOBILE	-	-	-	-	-	-	
AIRBORNE	181	4.069	44500.	49000.	-	-	
MISSILE	-	-	-	-	-	-	
SHIPBOARD	-	-	-	-	-	-	
SUBMARINE	-	-	-	-	-	-	
HELICOPTER	-	-	-	-	-	-	

ENVIRONMENTAL FACTORS									
NON-OPERATING		OPERATING							
G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H	
1.0	-	-	-	5200	-	-	-	-	

PART CATEGORY: VALVE, HYDRAULIC

DESCRIPTION: SPOOL, 4-WAY

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			
			BEST ESTIMATE	90% CONFIDENCE	RANGE	
			LOW	HIGH		
<u>NON-OPERATING</u>						
GROUND, FIXED	*	*	2.82	5.64	1.4	22.9
<u>OPERATING</u>						
SATELLITE	-	-	-	-	-	-
GROUND	-	-	-	-	-	-
GROUND, MOBILE	-	-	-	-	-	-
AIRBORNE	146	.838	174000.	194000.		
MISSILE	-	-	-	-	-	-
SHIPBOARD	-	-	-	-	-	-
SUBMARINE	-	-	-	-	-	-
HELICOPTER	-	-	-	-	-	-

ENVIRONMENTAL FACTORS									
NON-OPERATING			OPERATING						
G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H	
1.0	-	-	-	62000	-	-	-	-	-

\*See Valve, Hydraulic, General

PART CATEGORY: VALVE, OIL

DESCRIPTION: GENERAL

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			RANGE
			BEST ESTIMATE	90% CONFIDENCE	LOW	
<u>NON-OPERATING</u>						
GROUND, FIXED	*	*	12.4	15.8	-	32.3
<u>OPERATING</u>						
SATELLITE	-	-	-	-	-	
GROUND	12	2.844	4220.	6270.	-	
GROUND, MOBILE	-	-	-	-	-	
AIRBORNE	76	2.067	36800.	42800.	-	
MISSILE	-	-	-	-	-	
SHIPBOARD	-	-	-	-	-	
SUBMARINE	-	-	-	-	-	
HELICOPTER	-	-	-	-	-	

ENVIRONMENTAL FACTORS									
NON-OPERATING			OPERATING						
G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H	
1.0	-	340	-	3000	-	-	-	-	

\*See Valve, General

PART CATEGORY: VALVE, PNEUMATIC  
 DESCRIPTION: GENERAL

ENVIRONMENT	FAILURES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			RANGE	
			BEST ESTIMATE	90% CONFIDENCE	LOW		
<u>NON-OPERATING</u>							
GROUND, FIXED	1	4.67	214.	833.	-	1810.	
<u>OPERATING</u>							
SATELLITE	-	-	-	-	-		
GROUND	21	3.164	6640.	8900.			
GROUND, MOBILE	-	-	-	-			
AIRBORNE	4661	75.97	61400.	62500.			
MISSILE	-	-	-	-			
SHIPBOARD	-	-	-	-			
SUBMARINE	-	-	-	-			
HELICOPTER	-	-	-	-			

ENVIRONMENTAL FACTORS									
NON-OPERATING		OPERATING							
G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H	
1.0	-	31	-	290	-	-	-	-	

PART CATEGORY: VALVE, PNEUMATIC

DESCRIPTION: BLEED

ENVIRONMENT	FAIL- URES	PART HOURS (10 <sup>6</sup> )	FAILURE RATE IN FITS			RANGE
			BEST ESTIMATE	90% CONFIDENCE	LOW	
<u>NON-OPERATING</u>						
GROUND, FIXED	*	*	214.	833.	-	1810.
<u>OPERATING</u>						
SATELLITE	-	-	-	-	-	
GROUND	-	-	-	-	-	
GROUND, MOBILE	0	.543	<1840.	4250.		
AIRBORNE	1043	4.782	218000.	227000.		
MISSILE	-	-	-	-	-	
SHIPBOARD	-	-	-	-	-	
SUBMARINE	-	-	-	-	-	
HELICOPTER	10	.047	213000.	328000.		

ENVIRONMENTAL FACTORS									
NON-OPERATING			OPERATING						
G <sub>F</sub>	S <sub>A</sub>	G	G <sub>M</sub>	A	M	S <sub>H</sub>	S <sub>U</sub>	H	
1.0	-	-	9	1000	-	-	-	-	1000

\*See Valve, Pneumatic, General

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SIXTH QUARTERLY PROGRESS REPORT  
FOR  
MANUFACTURING METHODS AND TECHNOLOGY (MM&T)  
MEASURE FOR FABRICATION OF LOW VOLTAGE  
START SEALED BEAM ARC LAMPS  
1 Oct. 1977 to 31 Dec. 1977  
CONTRACT NO. DAAB07-76-C-0034

U.S. Army Electronics Command  
Production Division  
Production Integration Branch  
Ft. Monmouth, NJ 07703

Varian Associates  
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1 Oct. 77 - 31 Dec. 77

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
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**Block 20 Continued**

Improvements were made to reduce manufacturing costs and improve reliability. These included;

- a. Molybdenum insert was added to improve heat transfer from anode to heatsink,
- b. Anode base changed from steel to copper,
- c. Stinger bearings changed to sapphire to reduce friction,
- d. New mandrel machined and precision polished,
- e. Test bench set-up to evaluate individual reflectors for focal point location and relative output readings.
- f. Lamp with demountable electrodes designed to study electrode optimization,
- g. Stinger mechanism cycle tested and evaluated.

**MANUFACTURING METHODS AND TECHNOLOGY (MM&T)  
MEASURE FOR FABRICATION OF LOW VOLTAGE  
START SEALED BEAM A<sup>D</sup>C LAMPS**

**SIXTH QUARTERLY PROGRESS REPORT**

**1 Oct. 1977 to 31 Dec. 1977**

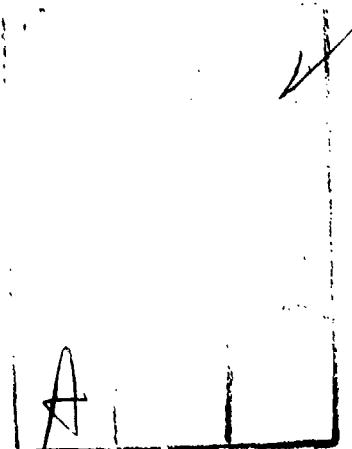
"The objective of this manufacturing methods and technology project is to establish the technology and capability to fabricate Low voltage Start Sealed Beam Arc Lamps".

**CONTRACT NO. DAAB07-76-C-0034**

**By**

Roy Roberts  
Tim Bell

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ABSTRACT

A program is in progress to establish a production capability for the purpose of meeting estimated military needs for the X6335, a 1kW sealed beam xenon arc lamp with a low voltage starting mechanism.

In accordance with the requirements of the contract, the third engineering sample is still undergoing fabrication to meet specifications.

## Table of Contents

<u>Section No.</u>	<u>Title</u>	<u>Page</u>
1.0	Purpose	1
2.0	Glossary	3
3.0	Narrative and Data	4
3.1	Design and Analysis	6
3.2	Fabrication & Tooling	12
3.3	Testing	13
3.3.1	Stinger mechanism	13
3.3.2	Reflectors	13
3.3.3	Pressure Test	14
3.4	Conclusion	14
4.0	Program for Next Interval	14
5.0	Publications and Reports	14
6.0	Identification of Personnel	15
7.0	Distribution List	18

## LIST OF FIGURES

<u>Fig. No.</u>	<u>Title</u>	<u>Page No.</u>
1	MM&T E.I. curve for lamps No. 12 and No. F7V193	8
2	MM&T Lamp, Front View	9
3	MM&T Lamp Side View	10
4	MM&T Lamp Rear View	11

## 1.0 PURPOSE

The objective of this program is to establish a production capability for the purpose of meeting estimated military needs for a period of two (2) years after completion of the contract, and to establish plans which may be used to meet expanded requirements.

The program is intended to demonstrate and to "prove-out" the manufacturing processes, methods and techniques that are utilized in the production of 1kW sealed beam xenon arc lamps with a low voltage starting mechanism.

The lamp initially chosen for the program was the X6257. This lamp was developed for military search-light applications. The high voltage version of this lamp was developed initially under Contract Number DAA02-68-C-0215. The 1kW lamp was further refined on a PEM Contract Number DAAB05-71-C-2609. The low voltage starting X6257 was not developed with government funds, but was developed with Varian funds.

This contract is divided into three phases:

1. Engineering Samples, wherein modifications are being made to designs arrived at under previous development in order to improve their optical performance, safety and utility in the field and to reduce their cost. Production drawings, procedures, and tooling will also be developed. These parameters will be based on delivery of three (3) samples.
2. Confirmatory Samples, wherein the delivery of three

- 3
- (3) units will be made to demonstrate that lamps can be made with production techniques and procedures to meet the specification.
3. Pilot run, wherein the delivery of thirty (30) units will be made to demonstrate the capability of meeting the planned production rate.

The engineering sample phase is needed to incorporate features which will make the lamp start more reliably, be easier to fabricate, be safer to operate, have a highly accurate mounting surface for optical reference and afford cost reduction.

During this quarter the 3rd Engineering sample underwent improvements to aid heat transfer at the anode base. Reflector location to the cathode tip on various lamp samples was evaluated to optimize candlepower readings.

## 2.0 GLOSSARY

LVS.....Low voltage starting.

Stinger.....Moveable electrode used for lamp ignition.

Mandrel.....A stainless steel tool which is polished to a mirrored surface with a special elliptical contour upon which the reflector is electroformed.

EI (characteristic).....The voltage (E) across the lamp for a given current (I) passing through the lamp.

PBC.....Peak beam candlepower

EMI.....Electromagnetic interference

### 3.0 NARRATIVE AND DATA

The lamp is comprised of conventional tungsten electrodes positioned in a ceramic/metal structure with a reflector and sapphire window. The arc is located at the focal point of the reflector so that a directed beam is obtained coaxial with the electrodes. The low voltage starting mechanism includes a moveable electrode called the "stinger" which is coaxial with the anode.

The lamp is filled with up to 20 atmospheres of high purity xenon at room temperature. The lamp's spectral output is a typical high pressure xenon arc spectrum as reflected from a silver mirror and transmitted through a sapphire window. The wavelength range is about 130nm to 6500nm. The silver reflector coating was selected for maximum output in the visible and near IR bands.

The lamp operating voltage is 19.5 D.C.  $\pm .5v$ . The lamp voltage is determined primarily by the inter-electrode gap and the lamp pressure. The lamp acts much like a constant voltage device, that is, large changes in current result in small changes in operating voltage. Ignition is accomplished by use of the stinger. To commence the start cycle, the solenoid voltage is applied causing the stinger to move forward. The moment the stinger contacts the cathode tip, the electrical circuit is completed and current begins to flow through the choke. After approximately .5 seconds, the solenoid voltage is removed and the stinger starts to return to its deenergized position, thus breaking the circuit.

At this time, the stored energy in the choke is dumped into the arc. The stinger then draws this arc back and transfers the arc to the anode.

To further MM&T progress the following items were investigated during this report period.

- a. Anode heat transfer.
- b. Anode stress at braze.
- c. Stinger bearings.
- d. Stinger life.
- e. Lamp body integrity.
- f. EI characteristics, stability, EMI.
- g. Lamp output (PBC)
- h. Cathode placement verses arc crossover points.
- i. Reflector mandrel contour.
- j. De-mountable electrode lamp.
- k. Stinger reliability relative to friction in bearings.
- l. Stinger vibration test.

### 3.1 DESIGN AND ANALYSIS

The following paragraphs describe work done during this report period.

1. Signs of melting were noted in the anode tip after operating the stinger mechanism over 1000 on-off cycles. A molybdenum insert was incorporated to improve heat transfer and thereby reduce anode tip temperature. This insert has been used effectively in the previous low voltage searchlight lamps. The molybdenum insert will also lower the stress at this joint interface.
2. The anode base material was changed from carbon steel to copper in conjunction with the molybdenum insert to improve heat transfer.
3. The anode cooling fins were brazed on the copper heatsink to improve heat transfer from the anode.
4. Stinger bearings were changed from molybdenum and ceramic to sapphire bearings. This improvement offers a lower part cost and lower coefficient of friction against the tungsten stinger shaft. Also stinger parts were silver coated to reduce friction between moving parts and improve electrical conductivity.
5. Functional test of stinger assembly to 6000 cycles, (30 sec. on and 30 sec. off) completed to date.
6. Lamp number 31 of the 3rd engineering sample phase was pressure checked to 1400 psi without rupturing.
7. New elliptical reflector mandrel was machined and controlled polished.

8. Voltage and current (EI) data was established on engineering samples No. 12 and F7V193. The following data (Figure 1) was generated to reflect EI characteristics for the two lamps. The steep shift in the EI occurred beyond 40 amps for engineering sample No. 12 and is attributed to anode braze deterioration which resulted in overheating the anode.  
Figure 1 also shows a comparison between an .085 inch gap and a .065 inch gap, for the two engineering samples. The decrease in gap spacing for lamp No.12 had shifted the EI curve closer to MM&T specifications as shown on the attached graph.
9. Peak Beam Candlepower for lamps 11 through 13 were recorded at 20 million candela instead of the 25 million candela specified in the MM&T specifications. The following areas were investigated to remedy the problem.
  - a. Cathode placement.
  - b. Reflector contour
  - c. Surface reflectances.
  - d. Cathode size and shape.
  - e. Reflector thickness.
10. Flanged elliptical reflectors were optically evaluated for beam crossover points as a possible cause for low peak beam candlepower of 20 M candelas. The theoretical beam crossover point is 2.600 inches from the reflector locating flange. The empirically recorded dimension was 3.6000 inches which severely limited the light beam filling the 5 inch diameter F/1.3 projection optics and thereby reduces PBC output.
11. The reflector mandrel contour was proven inaccurate which accounts for the low PBC output. A new mandrel was machined in efforts to solve the low PBC output problems.

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EFFECT OF BESSEY CO. INC.

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### M.M & T E.I. CURVE FOR LAMPS NO.12 & NO. F7U193

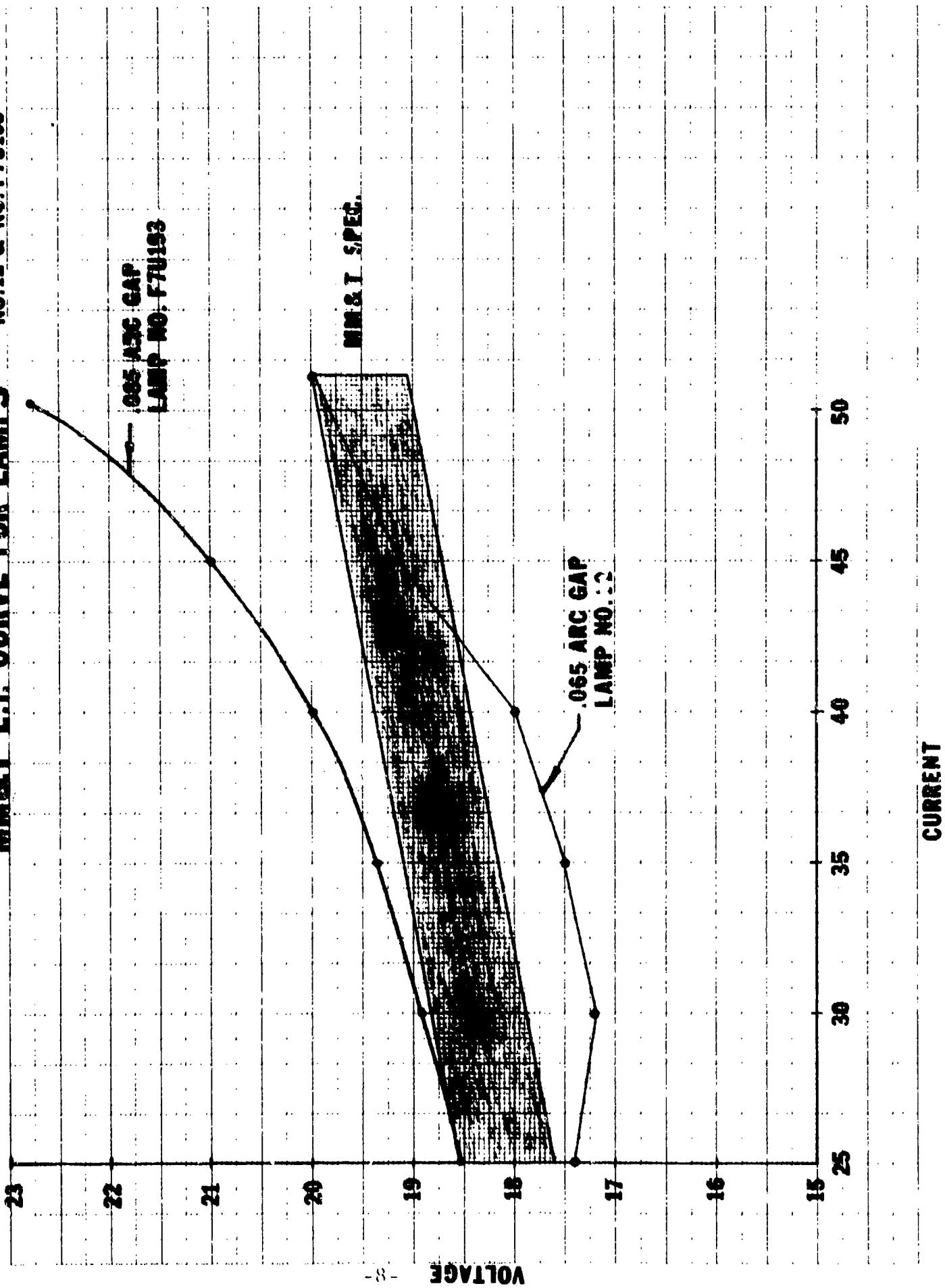


Figure 1

MM&T Lamp Front View

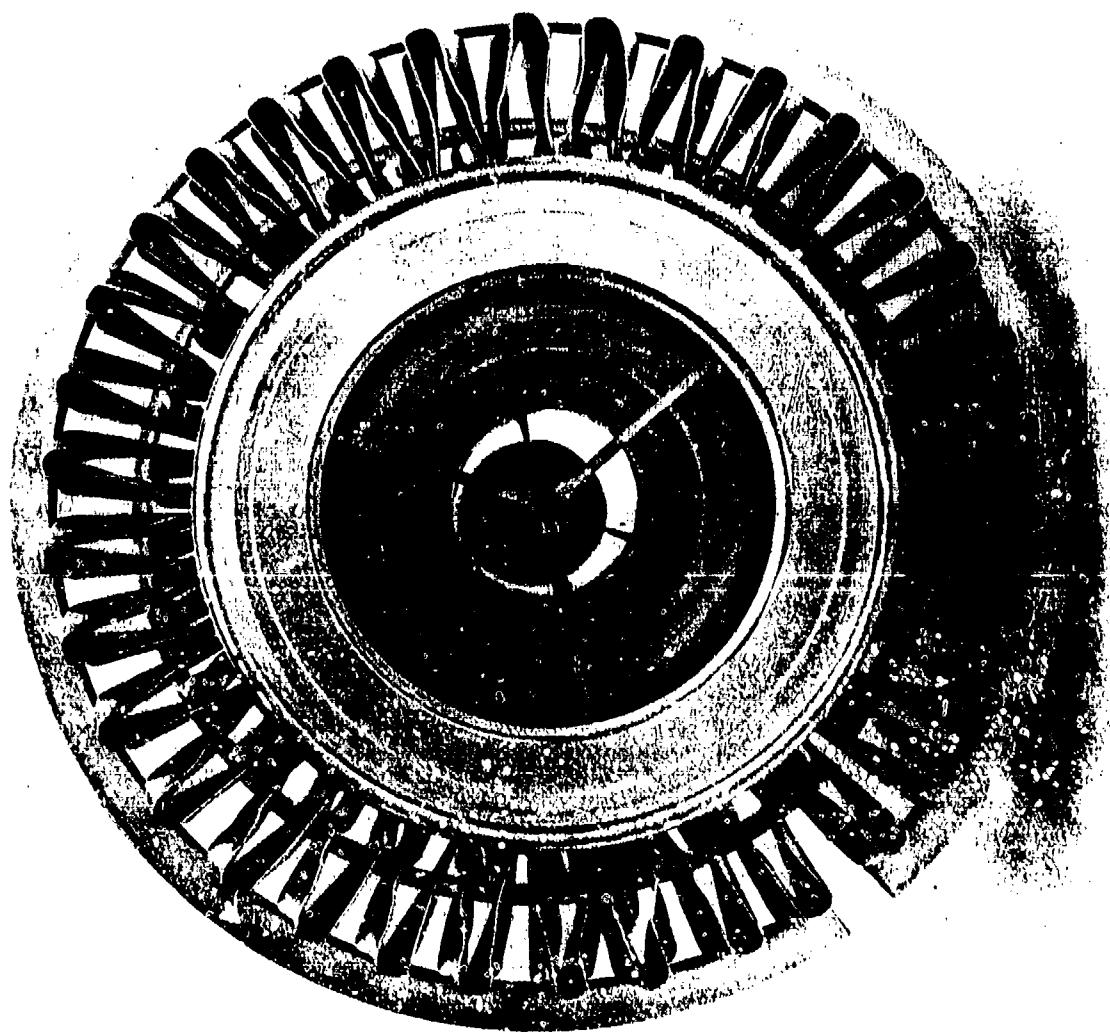


Figure 2 -9-

M&T Lamp Side View

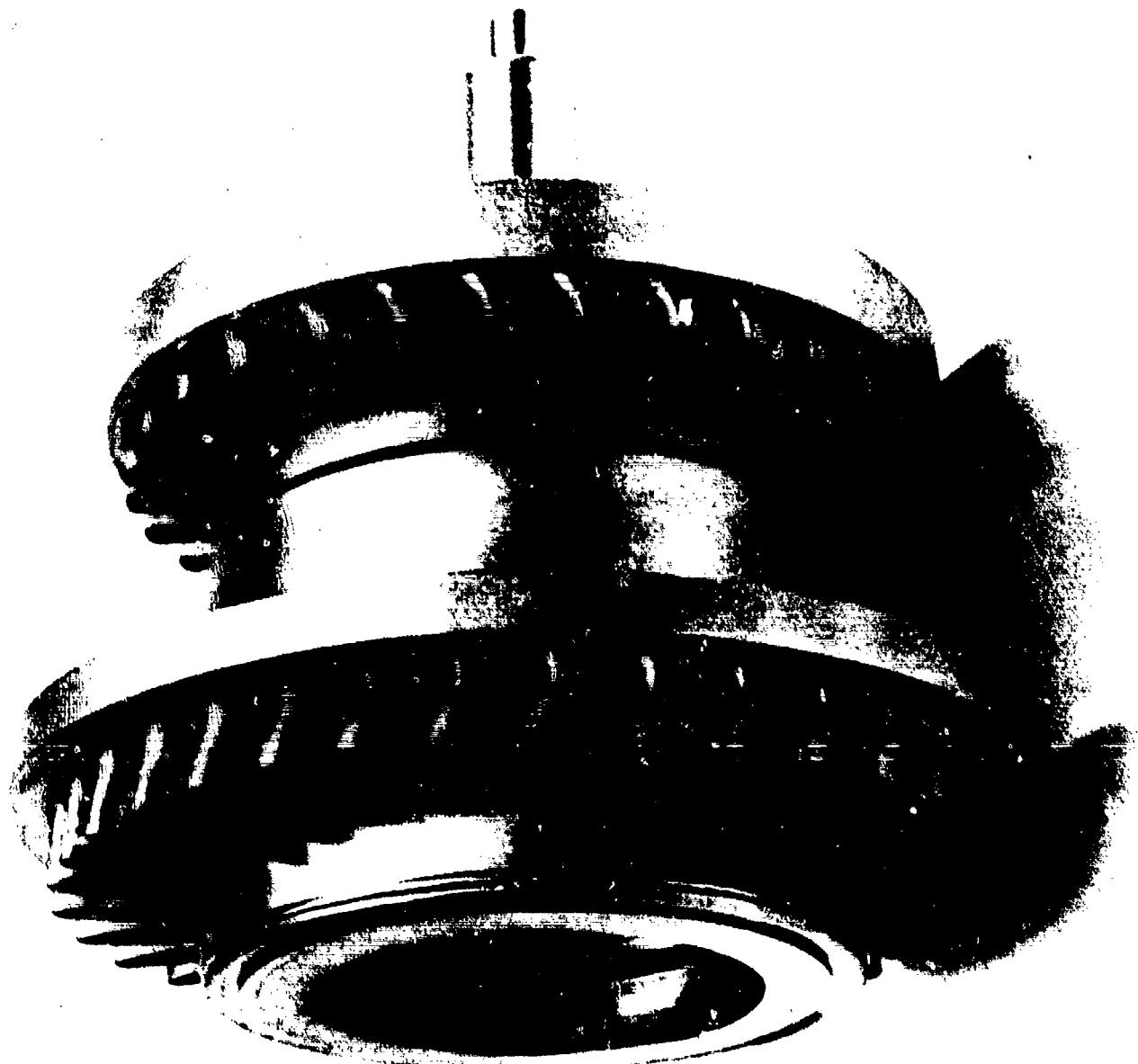


Figure 3 -10-

MM&T Lamp Rear View



Figure 4 -11-

### 3.2 FABRICATION AND TOOLING

Lamp body parts are being successfully brazed in sub-assemblies with pilot run tooling. Among the progress included is:

1. The molybdenum insert was successfully brazed into the copper heatsink to improve heat transfer from the tungsten anode.
2. New tooling was designed and built to accurately locate the stinger bearing centerlines. This tooling also has provisions to hold concentricity between the main body cup and the anode.
3. Machined parts for the improved stinger mechanism are completed and brazed.
4. The window assemblies were successfully brazed. The window metalizing was revised from copper plating to nickel in order to improve the joint strength.
5. Brazed sub-assemblies were made for the main body and anode cup seal rings.
6. A new flanged reflector mandrel was machined and precision polished to improve PBC output.
7. A lamp with demountable electrodes was designed and is now undergoing brazing operations. This project is totally funded by EIMAC but will be extremely valuable in electrode evaluation of this lamp as well as others.
8. Lamp sub-assemblies and additional tooling for the confirmatory run are being fabricated.
9. Braze washers for the window assembly and main body metal to ceramic seal are completed.
10. Additional sets of tooling are scheduled for manufacture after the initial tooling proves its reliability and effectiveness.

### 3.3 TESTING

#### 3.3.1 Stinger Mechanism

- a. A test was conducted to cycle the stinger mechanism with the lamp operating 50 sec. on and 10 sec. off. The anode showed signs of melting at the tip which ended the test at approximately 1000 cycles.
- b. Another test was set up to life cycle the stinger mechanism in a fully functional lamp to determine:
  1. Friction buildup as a function of time as determined by voltage increases in stinger solenoid.
  2. The effect of silver versus copper plated stinger parts. The test was conducted to 6000 cycles of 30 second intervals at 1kw of lamp power without any evidence of stinger mechanism failure.
- c. Stinger vibration tests were performed to determine the resonant frequency and stinger rod amplitudes for various stinger armature and spring mechanisms. The vibration loadings were performed coincident to the lamps centerline. At a 20g's vibration loading and a cyclic frequency sweep from 20 to 80 cycles per second no significant stinger movement was noted.

#### 3.3.2 Reflectors

A test has been established to optically verify the accuracy of the elliptical reflectors before installation in a lamp. In addition, this test determines the ideal cathode tip placement relative to the focal point for each reflector. Thus the

reflector focal point location is dimensionally established for each reflector permitting the reflector location and cathode strut position to be optimally established during assembly.

### 3.3.3 Pressure Test

- a. The lamp was subjected to a pressure test to evaluate the lamps pressure capability. The lamp body was subjected to 1400 psi of fill pressure without destruction.

### 3.4 CONCLUSION

Results of work accomplished during this report period indicate that major progress was made in solving problems associated with the following:

- a. Heat transfer from anode.
- b. Stinger mechanism reliability
- c. Reflector to cathode tip location
- d. Lamp body integrity

Completed lamp assemblies are reliably being brazed up to increase the number of sub-assemblies awaiting final lamp assemblies.

### 4.0 PROGRAM FOR NEXT INTERVAL

1. Finalize all detail drawings and assembly drawings for the MM&T lamp.
2. Investigate with an EIMAC funded de-mountable electrode lamp, the cathode and anode placement as a function of candlepower.
3. Continue to test lamps for reliability.
4. Incorporate improvements as required to optimize peak beam candlepower.

### 5.0 PUBLICATIONS AND REPORTS

None.

## 6.0 IDENTIFICATION OF PERSONNEL

The following is a list of key personnel who worked on this contract during the period October 1977 through December 1977.

Roy Roberts.....	199.0 Hours
Gordon Liljegren.....	24.0 Hours
Nick Picoulin.....	43.2 Hours
Welton Jones.....	345.5 Hours
Nick Cortese.....	71.2 Hours
Alice Estrada.....	35.6 Hours
Lavaughn Overton.....	6.0 Hours
Vic Kristen.....	2.0 Hours
Cheryl Handley.....	10.0 Hours (Draftperson)
Greg Guild.....	211.7 Hours "
Bob Fehringer.....	36.0 Hours "
Glenn Brown.....	8.0 Hours "
George Calkins.....	9.0 Hours "
Paul Wierenga.....	16.0 Hours "

The resume for Mr. Martin Wolfe and Ms. Alice Estrada are included in this report. Mr. Wolfe is a master technician with EIMAC and will be allocating appropriate time to the MM&T project. Ms. Estrada is a tube technician allocating appropriate time to the fabricating of braze assemblies of the MM&T project.

MARTIN E. WOLFE

Mr. Wolfe has been employed by EIMAC for thirty four years and is familiar with all areas of technology relating to lamp development. Mr. Wolfe's current responsibilities include brazing assemblies and design of brazing fixtures, and in the manufacture of xenon lamps.

Mr. Wolfe's recent experience includes new product development in the areas of cathodes, lasers, and traveling wave tubes. In addition, he assisted in developing ceramic metalizing techniques and the design and fabrication of ceramic to metal seals. This experience will be invaluable to further efforts on the MM&T lamp program.

Mr. Wolfe has also worked at a supervisory capacity in developing manufacturing methods and techniques for production workers in the vacuum industry.

ALICE R. ESTRADA

Ms. Estrada joined EIMAC in 1946 as a recent graduate of the College of San Mateo. Ms. Estrada started working in the testing department of the Vacuum Tube Division and moved progressively through the departments of the division and achieved supervisory status. This experience provided a professional background in the operation of the various types of machinery and techniques employed in the tube division.

Ms. Estrada then was assigned to the Advanced Products Model Shop as a technician, which furthered her knowledge in the areas of research and development. The techniques employed were quartz to metal seals, thin film deposition, vacuum system brazing and ionic evaporation sputtering. The major commodity areas were xenon arc lamps in pre-production development, Apollo Space Lights, Tow Lamp program, and presently on the one kilowatt low-voltage lamp. Ms. Estrada is presently making final assemblies for the xenon arc lamps initial stage to completion.

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12

TABLE 4-3. DEVICE FAILURE RATES FOR DEVICE USAGE (CONTINUED)

DEVICE TYPE	USAGE	TOTAL FAILURE RATE IN FITS PER DEVICE QUANTITY			
		$\lambda_{NO}$	$\lambda_O$	$\lambda_L$	$\lambda_F$
<u>Inductive Devices***</u>					
Coils	50	55.5	550.	3000.	1500.
Transformers	10	9.1	33.	180.	90.
Filters	200	110.	2200.	11000.	5600.
<u>Crystal</u>	3	117.9	630.	133332.	1332.
<u>Electromechanical</u>					
Accelerometer	3	89.1	157569.	120000.	709755.
Rate Gyro	5	665.	130025.	2708335.	1858860.
Switch	1	26.	271.	86400.	27870.
Push	2	34.2	5022.	172800.	13070.
Thermal					
<u>Hydraulic</u>					
Accumulator	1	32.5	55800.	1500.	118000.
Valve	1	1.4	2710.	15400.	14700.
Reed	6	51.2	16260.	562980.	267000.
Solenoid	1	380.	4220.	4180000.	109000.
Pump, Fixed Disp.	1	1.4	2990.	15620.	26200.
Filter	4	796.	504000.	8756000.	520000.
<u>Ordnance</u>					
Gas Generator	1				
S&A Device (Redundant)	2				
Solid Rocket Motor	1				
----- ONE SHOT DEVICE -- SEE RELIABILITY -----					
MODEL					

TABLE 4-4.  
SYSTEM FAILURE RATES

FAILURE RATE IN FITS

<u>PART TYPE</u>	$\lambda_{NO}$	$\lambda_O$	$\lambda_L$	$\lambda_F$
Electrical & Electronic				
Active	3609.1	65772.	736320.	330418.
Passive	688.0	66477.	921092.	120388.
TOTAL E&E	4297.1	132249.	1657412.	450906.
Electromechanical	814.3	292887.	3087535.	2609555.
Hydraulic	1262.5	585980.	13531500.	105490 .
Ordnance	-----	ONE SHOT DEVICE	---See Reliab. Model.	
TOTAL MISSILE LESS ORDNANCE	6373.9	1011116.	18276447.	4115361.

FIGURE 4-2 RELIABILITY CALCULATION

$$R - \{5 \text{ years}\} = e^{-\lambda_{NO}} (43890 \text{ hours}) ; \quad R_O (5 \text{ sec.}) = e^{-\lambda_O} (.001388 \text{ hours})$$

$$R_T(30 \text{ sec.}) = e^{-\lambda_L(0.008333 \text{ hours)}}, \quad R_F(30 \text{ sec.}) = e^{-\lambda_F(0.008333 \text{ hours)}}$$

REDUNDANT	SAFE & ARM
R(5 years)	$R_1(S\&A)R_2(S\&A) + R_1(S\&A)[1-R_2(S\&A)] + R_2(S\&A)[1-R_1(S\&A)]$ $= (.95836)(.95836) + (.95836)(.04164) + (.95836)(.04164)$

Total missile 5 year reliability is

$$R_{LC} = (.82842)(.96492)(.94609)(.97456)(.99827) = .735751$$

It is instructive to consider the relation between the non-operational and operational reliabilities. Not counting one shot devices the non-operational reliability of the missile after 5 years of storage is .75641. The operational reliability is .99981. The ratio of the unreliability (1 minus reliability) during storage to that during operation is 1282. The unreliability during storage is 1282 times the unreliability during operation. This, of course, is due to the fact that the missile will spend the overwhelming majority of its life in a non-operating condition. Similarly this points out the importance of a design to be tolerable to these conditions.

For general part types the ratio of non-operating to operating failure rates is shown in Table 4-5.

TABLE 4-5.

NON-OPERATING TO OPERATING FAILURE RATES

PART TYPE	$\lambda_{NO}$ IN FITS	$\lambda_O/\lambda_{NO}$	$\lambda_L/\lambda_{NO}$	$\lambda_F/\lambda_{NO}$
Electrical & Electronic				
Active	3609.1	18.	204.	92.
Passive	688.0	97.	1339.	175.
TOTAL E & E	4297.1	31.	386.	105.
Electromechanical	814.3	360.	3792.	3205.
Hydraulic	1262.5	464.	10718.	836.
TOTAL MISSILES LESS ORDNANCE	6373.9	159.	2867.	646.

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**APPENDIX A**

**HYBRID MICROELECTRONIC RELIABILITY**

A.1 Non-Operating Reliability

The range of types and complexities of hybrid circuits precludes the use of a single failure rate for all devices.

The non-operating data collected for hybrid devices is shown in Table A-1 and gives an overall non-operating failure rate of 35.1 failures per billion hours.

Source A data was extracted from a major dormancy study.

Source G data represents a special laboratory test.

Source H data represents low complexity digital devices in a laboratory storage environment.

Source J data represents circuits used in warheads under field storage conditions.

Missile H data represents linear thick film devices which exhibited aluminum/gold interface problems at the wire bonds during missile storage.

Missile I data represents digital and linear devices in a depot storage environment. These are probably the more complex devices in the data.

All data represents approximate Class B quality levels.

TABLE A-1. HYBRID IC NON-OPERATING DATA

SOURCE	AMB. TEMP.	TECHNOLOGY	NO. DEVICES	STORAGE HRS. (millions)	NO. FAILURES	FAILURE RATE IN FITS
Source A	25°C	Thin Film	-	43.246	1	23.1
Source G	125°C	Thin Film	104	.09	2	20408.
	150°C	Thin Film	191	.191	3	15707.
	25°C	Thick Film	-	3.964	0	(<252.3)
	150°C	Thick Film	156	.261	2	7663.
	200°C	Thick Film	11	.011	0	(<90090.)
	25°C	Thick Film	5834	38.0	0	(<26.3)
Source H	25°C	Thick Film	36	.3	0	(<3333.3)
	25°C	Thick Film	5215	50.0	4	80.0
	25°C	Thick Film	-	146.0	1	6.85
Source J	25°C	Thick Film	62118	986.9	32	32.4
Missile H	25°C	Thick Film	2070	20.6	0	(<48.5)
	25°C	Thick Film	8280	82.4	0	(<12.1)
	25°C	Thick Film	8280	82.4	0	(<12.1)
	25°C	Thick Film	16560	164.7	13	78.9
	25°C	Thick Film	4140	41.2	9	21.8
	25°C	Thick Film	2070	20.6	0	(<48.5)
	25°C	Thick Film	2070	20.6	0	(<48.5)
	25°C	Thick Film	2070	20.6	0	(<48.5)
	25°C	Thick Film	2070	20.6	1	48.5

## A.2 Hybrid Integrated Circuits Operational Prediction Model

The MIL-HDBK-217B failure rate model for hybrid microelectronic devices is:

$$\lambda_p = \lambda_b (\pi_T \times \pi_E \times \pi_Q \times \pi_F) \times 10^{-6}$$

where:

- $\lambda_b$  = base failure rate
- $\pi_T$  = temperature factor
- $\pi_E$  = environmental factor
- $\pi_Q$  = quality factor
- $\pi_F$  = circuit function factor

From the I.C. chip standpoint, the hybrid model is structured to accommodate all of the monolithic chip types and the various complexity levels.

Figure A-1 gives the hybrid model and values for each parameter. The base failure rate must be calculated and a description of this calculation is given below.

### A.2.1 Base Failure Rate, $\lambda_b$

The base failure rate equation is:

$$\begin{aligned} \lambda_b = & \lambda_s + A_s \lambda_c + \sum \lambda_{RT} N_{RT} \text{ (substrate contribution)} \\ & + \sum \lambda_{DC} N_{DC} \text{ (contribution of attached components)} \\ & + \lambda_{PF} \pi_{PF} \text{ (package contribution)} \end{aligned}$$

#### A. Substrate Contribution

$\lambda_s$  is the failure rate due to the substrate and film processing. It has a value of either 0.02 or 0.04 and is independent of the number of substrates. The value 0.02 applies if only thick film or only thin film substrates are used. The value 0.04 applies if both types are used.

$A_S \lambda_C$  is the failure rate contribution due to network complexity and substrate area. The values of  $\lambda_C$  (complexity term) are a function of the element density,  $N_E/A_S$ .  $A_S$  is the substrate area in square inches.

To compute complexity,  $A_S$  is obtained by summing the areas of all thick film substrates resulting in a single equivalent thick film substrate. An equivalent thin film substrate is determined similarly. However, when substrates are stacked, only the area of the bottom substrate shall be used to compute  $A_S$ . If a substrate contains only one device, it shall be considered a chip and shall not be considered a substrate for purposes of failure rate prediction.

$N_E$  is the total complexity expressed as

$$N_E = N_{LT} + N_{RT} + N_{DC}$$

where:

$N_{LT}$  = number of internal lead terminations. Normally, this would be 2 times the number of leads, but for beam leads and flip chips, this would be one for each connection. This includes the leads from substrate to external leads.

$N_{RT}$  = number of film resistors

$N_{DC}$  = number of discrete chip devices (each chip counts as one device)

As a convenience in estimating the number of terminations from the schematic, the following approximations may be used (it is always more desirable to count the actual lead terminations than to use the approximation):

$N_{LT}$ = No. of transistors	x 4
+ No. of diodes	x 2
+ No. of capacitors	x 4
+ No. of chip resistors	x 4
+ No. of conventionally pack-aged integrated circuit leads	x 2
+ No. of integrated circuit chip bond pads	x 2
+ No. of external hybrid package leads	x 2

For the single equivalent thick film substrate, the value for  $N_E$  is determined from the above rules. Then  $N_E/A_S$  is computed using the  $A_S$  obtained in accordance with the above rules. The value of failure rate per square inch,  $\lambda_C$ , is obtained from the following equations.

For thin film :

$$\lambda_{C1} = 4.7(10)^{-8} \left(\frac{N_E}{A_S}\right)^{2.082} \quad \text{for } 120 \leq \frac{N_E}{A_S} \leq 10,000$$

$$= .001 \quad \text{for } 10 \leq \frac{N_E}{A_S} \leq 120$$

For thick film:

$$\lambda_{C2} = 2.4(10)^{-14} \left(\frac{N_E}{A_S}\right)^{4.429} \quad \text{for } 250 \leq \frac{N_E}{A_S} \leq 2,000$$

$$= .001 \quad \text{for } 10 \leq \frac{N_E}{A_S} \leq 250$$

The final value of  $A_S \lambda_C$  requires the use of the same  $A_S$  used to determine  $N_E/A_S$ .

This procedure is then repeated for the thin film equivalent substrate. It should be noted that when  $N_E$  is computed for stacked substrates, the elements of the upper substrates are included with the bottom substrate, even though the upper substrate uses a different resistor technology than the bottom substrate (thin film or thick film or vice versa).

$\sum N_{RT} \lambda_{RT}$  is the sum of the failure rates for each resistor as a function of the required resistance tolerance.

$N_{RT}$  is the number of film resistors of a given tolerance.

$\lambda_{RT}$  is the failure rate to be used for each resistor of a given tolerance as specified in Figure A-1.

## B. Attached Components Contribution.

$\Sigma \lambda_{DC} N_{DC}$  is the sum of the attached device failure rates for semiconductors, integrated circuits, capacitors and resistors, both packaged and unpackaged. The failure rate is computed by multiplying the  $\lambda_{DC}$  by  $N_{DC}$ , the quantity of each type. The  $\lambda_{DC}$  is the same for a packaged or unpackaged device. The  $\lambda_{DC}$  values are in Figure A-1.

## C. Package Contribution.

$\lambda_{PF} \Pi_{PF}$  is the hybrid package failure rate which is a function of the package style or configuration and the materials used in its construction.

$\lambda_{PF}$  is 0.01 failure/ $10^6$  hr. This is a normalized value of base failure rate for all hybrid packages.

$\Pi_{PF}$  is an adjustment factor which modifies  $\lambda_{PF}$  as a function of the package style and materials. Its values are in Figure A-1.

### A.2.2 II Adjustment Factors

#### A.2.2.1 Temperature Adjustment Factor, $\Pi_T$

$\Pi_T$  adjusts the model for temperature acceleration factors. The values in Figure A-1 are derived from

$$\Pi_T = e^x$$

where  $x = -3411 \left( \frac{1}{T + 273} - \frac{1}{298} \right)$  for  $\Pi_{T1}$  if the temperature ( $^{\circ}C$ ) of the package mounting base is known, and

$x = -3794 \left( \frac{1}{T + 273} - \frac{1}{318} \right)$  for  $\Pi_{T2}$  if the highest temperature ( $^{\circ}C$ ) within the hybrid package is known.

$\Pi_T$  values are invalid at package mounting base temperatures above  $125^{\circ}C$  or for hot spot temperatures above  $175^{\circ}C$ .

#### A.2.2.2 Environmental Adjustment Factor, $\Pi_E$

$\Pi_E$  accounts for the influence of environmental factors other than temperature. Refer to the environment description in the appendix.

#### A.2.2.3 Quality Factor, $\Pi_Q$

$\Pi_Q$  accounts for effects of different quality levels. Classes A, B and C devices are those which have been subjected to, and passed all requirements, tests, and inspections specified in Methods 5004 and 5006 of MIL-STD-883, including screening, qualification, and quality conformance inspection requirements for the specified class.

#### A.2.2.4 Circuit Function Adjustment Factor, $\Pi_F$

$\Pi_F$  adjusts the model for circuit function, (i.e., digital or linear).

FIGURE A-1. MIL-HDBK-7B OPERATIONAL FAILURE RATE MODEL FOR HYBRID MICROELECTRONIC DEVICES

$$\lambda_p = \lambda_b (\Pi_T \times \Pi_E \times \Pi_Q \times \Pi_F) \times 10^{-6}$$

$$\lambda_b = \lambda_s + \lambda_s^2 C + \sum \lambda_{RT} N_{RT} + \sum \lambda_{DC} N_{DC} + \lambda_{PF} \Pi_{PF}$$

$\lambda_s$  (Substrate Failure Rate)

$\lambda_s = .02$ if only thick film or only thin film
$\lambda_s = .04$ if both thick film and thin film

$A_s$  (Substrate Failure Rate Modifier)

$A_s = \text{Substrate Area in Square Inches.}$

$\lambda_C$  (Complexity Term)

See next page

$\lambda_{RT}$  (Resistor Tolerance Factor)

Resistor Tolerance (-Percent)	Thin Film Resistors	Thick Film Resistors
0.1 to 1.0	0.00050	-
1.0 to 5.0	0.00025	0.00050
5.0	0.00010	0.00012

$N_{RT}$  = # of Resistors of a Given Tolerance

$\lambda_{DC}$  (Attached Devices Term)

See next page

$N_{DC}$  = # of attached devices of a given type.

$\lambda_{PF}$  (Package Failure Rate)

0.01
------

$\Pi_T$ (Temperature Factor)					
$T$ ( $^{\circ}$ C)	$\Pi_{T1}$	$\Pi_{T2}$	$T$ ( $^{\circ}$ C)	$\Pi_{T1}$	$\Pi_{T2}$
25	1.0	.45	105	1.1	6.66
30	1.2	.55	110	1.3	7.6
35	1.5	.68	115	1.4	8.6
40	1.7	.83	120	1.6	9.7
45	2.1	1.0	125	1.8	11.
50	2.4	1.2	130	-	12.
55	2.8	1.4	135	-	14.
60	3.3	1.7	140	-	16.
65	3.9	2.0	145	-	17.
70	4.5	2.4	150	-	19.
75	5.2	2.8	155	-	21.
80	6.0	3.3	160	-	24.
85	6.8	3.8	165	-	26.
90	7.8	4.4	170	-	29.
95	8.8	5.1	175	-	32.
100	10.0	5.8			

$\Pi_E$ (Environment Factor)	$\Pi_E$
Ground, Benign	0.2
Space Flight	0.2
Ground, Fixed	1.0
Airborne, Inhab.	4.0
Naval, Sheltered	4.0
Ground, Mobile	4.0
Naval, Unshelt.	5.0
Airborne, Uninhab.	6.0
Missile, Launch	10.0



**APPENDIX B**  
**ORDNANCE DEVICE RELIABILITY**

### **B.1 Solid Propellant Rocket Motors**

The reliability of solid propellant motors is a one-shot reliability and is not considered dependent on the operational time of the unit. The motors, however, do demonstrate definite aging trends in ballistic parameters during long term storage.

The reliability prediction for solid propellant motors therefore is a single probability of success for the total life cycle of the unit. Table B-1 gives the reliability estimates for various classes of motors. The reliability of the ignition system is not included in this prediction but presented separately in Section B.2.

Two general propellant compositions are considered: Double Base and Composite. Also each propellant composition is divided into single thrust and dual thrust motors.

The estimates for the motors are considered conservative.

TABLE B-1. PROPELLANT UNIT RELIABILITY  
(excludes ignition systems)

Classification	Reliability		
	50% Confidence	90% Confidence	
	5 yrs.	10 yrs.	5 hrs.
Double Base, Single Thrust	.930	.925	.795 .790
Double Base, Dual Thrust	.952 *	* .850	*
Composite, Single Thrust	.992	.924	.972 .790
Composite, Dual Thrust	.944 *	* .827	*
All Motors	.994	.964	.981 .890

\*No data available at 10 years.

## B.2 Igniter and Safe and Arm Devices

The reliability of igniters and safe and arm devices is a one-shot reliability and is not considered dependent on the operational time of the unit. These units do demonstrate definite aging trends in ballistic and functional parameters during long term storage. In addition, random type failures have also been experienced.

The reliability prediction model for the total life cycle of the device is:

$$R_{LC}(t) = [R(t) \text{ aging}] \times [R(t) \text{ random}]$$

where:  $R_{LC}(t)$  is the life cycle reliability of the unit  
 $R(t)$  aging is the aging component of the unit's reliability

$R(t)$  random is the random failure component of the unit's reliability and is equal to  $e^{-\lambda t}$ .

$\lambda$  is the random failure rate

$t$  is the total storage time of the unit.

Tables B-2 and B-3 contain values for the equation parameters for Igniters and Safe and Arm Devices respectively.

TABLE B-2. IGNITER RELIABILITY PREDICTION MODEL

$$R(t)_{\text{Igniter}} = [R(t)_{\text{aging}}] \times [R(t)_{\text{random}}]$$

$$R(t)_{\text{random}} = \exp(-\lambda t)$$

Classification	R(t) Aging			$\lambda$		
	50% confidence $t = 5$ yrs.	$t = 10$ yrs.	90% confidence $t = 5$ yrs.		50% Confidence $t = 10$ yrs.	90% Confidence
Solid Rocket Motor						
Pyrogen Igniters	.998	.996	.994	.954	$65 \times 10^{-9}$	$129 \times 10^{-9}$
Solid Rocket Motor						
Pyrotechnic Igniters	.995	.991	.984	.969	$65 \times 10^{-9}$	$129 \times 10^{-9}$
Gas Generator						
Igniters	.997	.979	.991	.934	$65 \times 10^{-9}$	$129 \times 10^{-9}$

\* Extrapolated

TABLE B-3 . SAFE AND ARM DEVICE RELIABILITY PREDICTION MODEL

$$R(t)_{\text{safe device}} = [R(t)_{\text{aging}}] \times [R(t)_{\text{random}}]$$

$$R(t)_{\text{random}} = \exp(-\lambda t)$$

Classification	R(t) aging		50% confidence $t = 5 \text{ yr.}$	90% confidence $t = 5 \text{ yr.}$	50% confidence $t = 10 \text{ yr.}$	90% confidence $t = 10 \text{ yr.}$
	$t = 5 \text{ yr.}$	$t = 10 \text{ yr.}$				
Inertial SEA	.992	.976	.975	.923	$58 \times 10^{-9}$	$91 \times 10^{-9}$
Manual SEA	1.000	1.000	1.000	1.000	$58 \times 10^{-9}$	$91 \times 10^{-9}$
Motor Driven SEA	.964	.954*	.948	.912*	$15 \times 10^{-9}$	$35 \times 10^{-9}$

\*Extrapolated from 1 through 8 year data.

### B.3 Solid Propellant Gas Generators

The reliability of solid propellant gas generators is a one-shot reliability and is not considered dependent on the operation time of the unit. The motors, however, do demonstrate definite aging trends in ballistic parameters during long term storage.

The reliability prediction for solid propellant gas generators therefore is a single probability of success for the total life cycle of the unit. Table B-4 gives the reliability estimates for gas generators. The reliability of the ignition system is not included in this prediction but presented separately in Section B.2

The estimates for the gas generators are considered conservative.

TABLE B-4. GAS GENERATOR RELIABILITY PREDICTION  
(excludes ignition systems)

<u>50% Confidence</u>		<u>90% Confidence</u>	
<u>5 Yrs.</u>	<u>10 Yrs.</u>	<u>5 Yrs.</u>	<u>10 Yrs.</u>
.991	.925	.972	.775

#### B.4 Miscellaneous Ordnance Devices

The reliability of ordnance devices is a one-shot reliability and is not considered dependent on the operation time of the unit. The units do exhibit a random failure characteristic in storage however.

The reliability prediction for the ordnance device for the unit's total life cycle is:

$$R_{LC}(t) = e^{-\lambda_p t}$$

where  $\lambda_p$  is the device storage failure rate  
t is the total storage hours

Table B-5 presents failure rate values for the various ordnance devices.

Failure rates for explosive bellows, explosive bolts, explosive motors and explosive timers are considered conservative.

FIGURE B-5. MISCELLANEOUS ORDNANCE DEVICE FAILURE RATES

$\lambda_p$  (Device Failure Rate)

Device	$\lambda_p$
Electric Igniters	.019 x $10^{-6}$
Explosive Actuators	.063 x $10^{-6}$
Explosive Bellows*	.015 x $10^{-6}$
Explosive Bolts*	.061 x $10^{-6}$
Explosive Motors*	.042 x $10^{-6}$
Explosive Switches	.005 x $10^{-5}$
Explosive Timers*	.035 x $10^{-6}$
Zero Impulse Bolt*	.926 x $10^{-6}$
Pin Puller*	.535 x $10^{-6}$
Surface Fuse	3.390 x $10^{-6}$
Energy Generator	1.863 x $10^{-6}$

\*Estimates considered conservative.

**APPENDIX C**  
**VACUUM TUBE RELIABILITY**

### C.1 Non-Operating Reliability

The failure rate models are presented in Figure C-1. Note, for a number of the tube types, a decreasing failure rate with time is indicated and described by a Weibull model.

For some tubes, the analysis indicated a significant decrease in failure rate with storage length for a large majority of the data. This suggested that the devices were failing very early in storage and no significant increase in failure occurred as time increased. The data was fit to a Weibull failure distribution in the form:

$$\lambda(t) = e^{(\beta-1)Lnt - Lna}$$

where  $\lambda(t)$  is the hazard rate or instantaneous failure rate per billion hours.

$\beta$  = shape parameter

$a$  = scale parameter

$t$  = storage hours in billions

A fairly high correlation was made to this function, with the  $\beta$  (shape) parameter less than one, again suggesting that the majority of the failures were occurring early in storage.

### C.2 Electronic Vacuum Tube Operational Prediction Model

The MIL-HDBK-217B failure rate model for electronic vacuum tubes is:

$$\lambda_p = \lambda_b \pi_E \times 10^{-6}$$

where  $\lambda_b$  = base failure rate in million hours

$\pi_E$  = environmental factor

The values for these parameters are shown in Tables C-1 and C-2. The base failure is valid provided tubes are replaced before wearout.

FIGURE C-1 ELECTRONIC VACUUM TUBE NON-OPERATING FAILURE RATE MODELS AND PARAMETERS

TUBE TYPE	FAILURE RATE MODEL	$\lambda_b$	$\alpha$	$\beta$
Receiving	$\lambda = \lambda_b$	12	-	-
Klystron, Low Power	$\lambda = \lambda_b$	78	-	-
Klystron, High Power	$\lambda(t) = e^{(\beta-1)Int - \ln \alpha}$	-	1.0106	0.269
TWT, Low Power & High Power	$\lambda(t) = e^{(\beta-1)Int - \ln \alpha}$	-	1.0243	0.314
Magnetron, Low Power & High Power	$\lambda(t) = e^{(\beta-1)Int - \ln \alpha}$	-	1.0467	0.310
Gridded Tubes, Low Power, High Power	$\lambda(t) = e^{(\beta-1)Int - \ln \alpha}$	-	1.0194	0.254
Amplitrons	$\lambda(t) = e^{(\beta-1)Int - \ln \alpha}$	-	0.9854	0.214

$\lambda$  = failures per billion hours       $t$  = storage time in billion hours

TABLE C-1. BASE FAILURE RATES FOR TUBES

TUBE TYPE	$\lambda_b$ (f./ $10^6$ hr.)
<b>RECEIVER</b>	
Triode, Tetrode, Pentode	5
Power Rectifier	10
<b>KLYSTRON</b>	
Low Power (e.g., local oscillator)	30
High Power	
VA853	200
VA842	50
L3403	150
L3035	85
SAC42A	110
L3250	110
Z5010	190
ZM3038A	350
If high power type not included above:	
Peak Power <10 Megawatts	200
Peak Power $\geq$ 10 Megawatts	400
<b>MAGNETRON</b>	
Peak Power <10 Kilowatts	200
Peak Power $\geq$ 10 Kilowatts	450
<b>TWT</b>	
Peak Power <100 watts	30
Peak Power $\geq$ 100 watts, <10,000 watts	100
Peak Power $\geq$ 10,000 watts	200
<b>CROSSED FIELD AMPLIFIER</b>	
QK681	180
<b>TRANSMITTING</b>	
Triode	75
Pentode	100
CRT	15
THYRATRON	50

TABLE C-2. ENVIRONMENTAL FACTOR FOR TUBES

ENVIRONMENT	G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	A <sub>U</sub>	N <sub>J</sub>	M <sub>L</sub>
R <sub>E</sub>	0.5	0.5	1.0	6.5	6.5	10	10	10	80

**APPENDIX D**  
**LASER OPERATIONAL PREDICTION MODELS**

#### D.1 Laser Operational Prediction Models

The MIL-HDBK-217B general failure rate model for lasers is:

$$\lambda_{\text{LASER}} = \lambda_{\text{MEDIA}} + \lambda_{\text{PUMP}} + \lambda_{\text{COUPLING}}$$

The models and failure rates apply to the laser peculiar items only, i.e., those items wherein the lasing action is generated and controlled. In addition to the laser peculiar items, there are other assemblies used with lasers that contain electronic parts and mechanical devices (pumps, valves, hoses, etc.). The failure rates for these parts should be determined with the same procedures as used for other electronic and mechanical devices in the equipment or system of which the laser is a part.

The laser failure rate models have been developed at the "functional," rather than "piece part," level because the available data were not sufficient for "piece part" model development.

Because each laser family can be designed using a variety of approaches the failure rate models have been structured on three basic laser functions which are common to most laser families, but may differ in the hardware implementation of a given function. These functions are the lasing media, laser pumping mechanism (or pump), and the coupling method.

Examples of media-related hardware and influence factors are the solid state rod, gas, gas pressure, vacuum integrity, gas mix, outgassing, and tube diameter. The electrical discharge, the flashlamp, and energy level are examples of pump-related hardware and influence factors. The coupling function contributors are the "Q" switch, mirrors, windows, cry hals, substrates, coatings, and level of dust protection provided.

The  $\lambda_{\text{PUMP}}$  term in the  $\lambda_{\text{LASER}}$  equation is zero for helium/neon, argon ion CO<sub>2</sub> sealed and CO<sub>2</sub> flowing lasers because the pumping mechanisms for these lasers contain no laser peculiar items. Pumping is accomplished with electrical parts and circuitry. Failure rates for these parts are not included in this section but they should be included in the reliability analysis of the system equipment containing the laser. Also,

some of the terms in the above general  $\lambda_{LASER}$  equation have modifying factors depending upon the laser type. These factors are shown in the following sub-sections.

#### D.1.1 Helium/Neon Argon Ion Lasers

The failure rate model for helium/neon and argon ion lasers is presented in Figure D-1.

The predominant failure mechanism is related to the gas media as reflected in  $\lambda_{MEDIA}$ . However for argon ion lasers, when the tube is refilled periodically (preventive maintenance) the mirrors (part of  $\lambda_{COUPLING}$ ) can be expected to deteriorate after approximately  $10^4$  hours of operation if in contact with the discharge region.

#### D.1.2 Carbon Dioxide, Sealed Lasers

The failure rate model for carbon dioxide sealed lasers is presented in Figure D-2.

The overfill percentage in the Gas Overfill Factor,  $\pi_0$ , is based on the percent increase over the optimum CO<sub>2</sub> partial pressure which is normally in the range of 1.5 to 3 Torr for most sealed CO<sub>2</sub> lasers. The equation for  $\pi_0$  is:

$$\pi_0 = -0.01 (\% \text{ overfill}) + 1$$

the equation for the ballast factor,  $\pi_B$ , is

$$\pi_B = (1/3) \frac{\% \text{ Vol. Inc.}}{100}$$

The number of active optical surfaces,  $\pi_{OS}$ , is determined from Figure D-5.

#### D.1.3 Carbon Dioxide, Flowing Lasers

The failure rate model for carbon dioxide, flowing lasers is presented in Figure D-3.

The failure rate contribution of the lasing media,  $\lambda_{MEDIA}$ , approaches zero for carbon dioxide, flowing lasers. This is because this type of laser is much less susceptible to leaks and long term gas decomposition than a sealed system. The flowing gas also acts as a purge in removing contamination and precluding its entrapment. Therefore, except for tube breakage (which has rarely been observed) optics deterioration appears the

predominant failure mechanism and this is accounted for under  $\lambda_{COUPLING}$ .

The failure rate contribution of the laser coupling hardware,  $\lambda_{COUPLING}$ , is a function of the laser beam average power output,  $P$ , in kilowatts. The  $\lambda_{COUPLING}$  values shown are valid only for power levels up to one kilowatt. Beyond this range other glass failure mechanisms begin to predominate and alter the  $\lambda_{COUPLING}$  values. It should also be noted that CO<sub>2</sub> flowing laser optical devices are the primary source of failure occurrence. A preventive maintenance program on optical devices would greatly extend laser life; however, procedures must be tailored to the individual design of each system. Typical optical cleaning methods are as follows:

1. Use dry, pressurized air and a camel hair brush to remove dust, particulates, etc.
2. Rub with high quality lens tissue using moisture from breath (if necessary).
3. Flush with distilled water and a mild laboratory detergent (if necessary).
4. Cautions -
  - a. Use of special gloves for handling recommended.
  - b. Careful use of 20 to 30 percent alcohol solutions with sterile cotton swabs (change swabs frequently).

The number of active optical surfaces,  $N_{OS}$  is determined from Figure D-5.

#### D.1.4 Solid State Nd:YAG Rod Lasers and Ruby Red Laser

The failure rate model for solid state neodymium doped yttrium-aluminum-garnet (Nd:YAG) rod laser and ruby red laser is presented in Figure D-4.

The failure rate contribution of the lasing media,  $\lambda_{MEDIA}$ , is 0.1 for Nd:YAG lasers. For the ruby red laser,  $\lambda_{MEDIA}$  is a function of the repetition rate ( $N_{REP}$ ) and the energy density (F) is measured in Joules per cm.<sup>2</sup>/pulse over the cross-sectional area of the laser rod and its value is determined from the actual design parameter of the laser rod utilized.

Repetition rates for military solid state lasers are generally in the 1 to 20 pps range. Repetition rates other than shown have not been observed and corresponding  $\pi_{REP}$  values certified.

The failure rate contribution of pumping mechanism,  $\lambda_{PUMP}$ , is highly affected by the flashlamp or flash tube contribution. It is expressed as a function of the environmental factor ( $\pi_E$ ) and the failure rate contribution of the flashlamp or flashtube ( $\lambda_{PUMP\ HOURS}$ ). The value for  $\lambda_{PUMP\ HOURS}$  is calculated from Figure D-6 for Xenon flashlamps or Figure D-7 for Krypton flashlamps.

It should be noted that although sealed systems tend to be reliable once compatible materials have been selected and proven, extreme care must still be taken to prevent the entrance of particulates during manufacturing, field flashlamp replacement, or routine maintenance/repair. Contamination is the major cause of solid state laser malfunction, and special provisions and vigilance must continually be provided to maintain the cleanliness level required. Coupling cleanliness factor,  $\pi_C$ , values can vary from 1 up to 60.

The number of active optical surfaces,  $\pi_{OS}$ , is determined from Figure D-5.

FIGURE D-1. MIL-HDBK-217B OPERATIONAL FAILURE RATE MODEL  
FOR HELIUM/NEON LASERS AND ARGON ION LASERS

$$\lambda = (\pi_E \lambda_{\text{MEDIA}} + \pi_E \lambda_{\text{COUPLING}}) \times 10^{-6}$$

$\lambda_{\text{MEDIA}} \& \lambda_{\text{COUPLING}}$		
Laser Type	$\lambda_{\text{MEDIA}}$	$\lambda_{\text{COUPLING}}$
Helium/Neon	84	.1
Argon Ion	457	6.

$\pi_E$ (Environmental Factor)	$\pi_E$
Environment	
Ground, Benign	.2
Space Flight	.2
Ground, Fixed	1.
Airborne, Inhabited	5.
Naval, Sheltered	5.
Ground, Mobile	5.
Naval, Unshelt.	5.
Airborne, Uninhab.	8.
Missile, Launch	8.

FIGURE D-2. MIL-HDBK-217B OPERATIONAL FAILURE RATE MODEL  
FOR CARBON DIOXIDE, SEALED LASERS

$$\lambda_{CO_2 \text{ SEALED}} = (\pi_E \pi_O \pi_B \lambda_{MEDIA} + \pi_E \pi_{OS} \lambda_{COUPLING}) \times 10^{-6}$$

$\pi_{OS}$  (Number of active Optical Surfaces)

See Figure 2.2-5

$\pi_E$  (Environmental Factor)

Environment	$\pi_E$
Ground, Benign	.2
Space Flight	.2
Ground, Fixed	1.
Airborne, Inhabited	5.
Naval, Sheltered	5.
Ground, Mobile	5.
Naval, Unsheltered	5.
Airborne, Uninhab.	8.
Missile, Launch	8.

$\lambda_{MEDIA}$	$I = 69I - 450$
$I =$ Current (ma) through discharge tube $(10\text{ma} \leq I > 150 \text{ ma})$	

$\lambda_{COUPLING}$

$\lambda_{COUPLING} = 10.$

$\pi_O$  (Gas Overfill Factor)

CO <sub>2</sub> Overfill Percent	$\pi_O$
0	1.00
25	0.75
50	0.50

$\pi_B$  (Ballast Factor)

Percent of Ballast Volumetric Increase	$\pi_B$
0	1.0
50	0.58
100	0.33
150	0.19
200	0.11

FIGURE D-3. MIL-HDBK-217B OPERATIONAL FAILURE RATE MODEL  
FOR CARBON DIOXIDE, FLOWING LASERS

$$\lambda_{CO_2 \text{ FLOWING}} = (\pi_E \lambda_{MEDIA} + \pi_E \pi_{OS} \lambda_{COUPLING}) \times 10^{-6}$$

$\lambda_{MEDIA}$	0
-------------------	---

$\pi_E$  (Environmental Factor)

Environment	$\pi_E$
Ground, Benign	.2
Space Flight	.2
Ground, Fixed	1.
Airborne, Inhabited	5.
Naval, Sheltered	5.
Ground, Mobile	5.
Naval, Unsheltered	5.
Airborne, Uninhab.	8.
Missile, Flight	8.

$\pi_{OS}$  (Number of active Optical Surfaces)

See Figure 2.2-5

Power (kilowatts)	$\lambda_{COUPLING}$
.01	3
.1	30
1.0	300*

\*Does not apply for power levels over 1.0 kilowatts.

FIGURE D-4. MIL-HDBK-217B OPERATIONAL FAILURE RATE MODEL  
FOR SOLID STATE Nd:YAG ROD LASERS AND RUBY RED LASERS

$$\lambda = (\Pi_E \lambda_{\text{MEDIA}} + \lambda_{\text{PUMP}} + \Pi_E \Pi_C \Pi_{\text{OS}} \lambda_{\text{COUPLING}}) \times 10^{-6}$$

$\lambda_{\text{MEDIA}}$  (Nd:YAG Rod Laser)

$\lambda_{\text{PUMP}}$

$$\lambda_{\text{PUMP}} = \Pi_E \lambda_{\text{PUMP}} \text{ HOURS}$$

$\lambda_{\text{E}}$  (Environmental Factor)

Environment	
Ground, Benign	.2
Space Flight	.2
Ground, Fixed	.1
Airborne, Inhabited	.5
Naval, Sheltered	.5
Ground, Mobile	.5
Naval, Unsheltered	.5
Airborne, Uninhab.	.8
Missile, Launch	.8

$\lambda_{\text{MEDIA}}$  (Ruby Red Laser)

$\lambda_{\text{PUMP}}$

Lamp?	See Figure
Xenon	B-6
Krypton	B-7

$\lambda_{\text{MEDIA}} = (\Pi_{\text{REP}}) (43.5 F^2.52)$

F = Energy density in Joules per cm<sup>2</sup>/pulse over the cross sectional area of the laser beam.

$\lambda_{\text{COUPLING}}$

$\Pi_{\text{REP}}$  (Repetition Rate Factor)

Repetition or Pulse Rate (Pulses per sec.)	$\Pi_{\text{REP}}$
1	3600
5	18000
10	36000
15	54000
20	72000

$\lambda_{\text{COUPLING}} = 16.3$

$\Pi_{\text{OS}}$  (Number of Active Optical Surfaces)

See Figure B-5

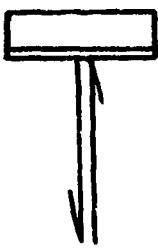
$\lambda_{\text{COUPLING}}$

$\Pi_C$	(Coupling Cleanliness Factor)
Rigorous cleanliness procedures, equipment, and trained maintenance personnel, plus bellows provided over optical train.	1
Minimal precautions during opening, plus bellows provided over optical train.	30
Minimal precautions during opening, maintenance, repair, and testing. plus bellows provided over optical train.	60

FIGURE D-5. EXAMPLES OF ACTIVE OPTICAL SURFACES AND COUNT

One active optical surface  
(count = 1)

Totally Reflective  
(TR) Mirror

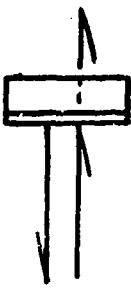


Two active optical surfaces  
(count = 2)

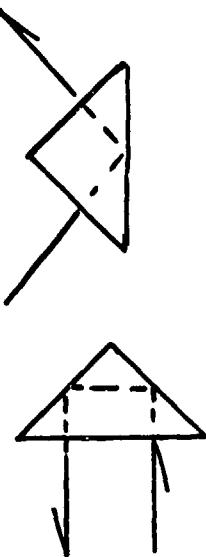
Lens/Window



Partially Reflective (PR) Mirror



Prism\*



Laser Beam

\*Prism has only 2 active surfaces, because interior surfaces are not subject to external particulate contamination.

Only active optical surfaces are counted. An active optical surface is one with which the laser energy or beam interacts. Internally reflecting surfaces are not counted.

FIGURE D-6. DETERMINATION OF  $\lambda_{PUMP}$  FOR XENON FLASHLAMPS  
HOURS

$$\frac{\lambda_{PUMP}}{\text{HOURS XENON}} = (\pi_{REP}) \left[ 2000 \left( \frac{E_j}{dL} \right)^{8.58} \right] (\pi_{COOL})$$

where:

$\lambda_{PUMP}$  is the failure rate contribution of the xenon flashlamp or flashtube\* in failures/million operating hours. The flashlamps evaluated herein are linear types used for military solid state laser systems.

$\pi_{REP}$  is the pulse or repetition factor used to convert from failures per  $10^6$  pulses to failures/million hours.

Repetition or Pulse Rate (Pulses per second)	$\pi_{REP}$
1	3600
5	18000
10	36000
15	54000
20	72000

$E_j$  is the flashlamp or flashtube input energy per pulse in joules and its value is determined from the actual or design input energy parameter except that for input energy levels equal to or less than 30 joules,  $E_j = 30$ .

$d$  is the flashlamp or flashtube inside diameter in millimeters, and its value is determined from the actual design parameter of the flashlamp utilized.

$L$  is the flashlamp or flashtube arc length in inches, and its value is determined from the actual design parameter of the flashlamp utilized.

$T$  is the truncated pulse width in microseconds, and its value is determined from the actual design parameter of the pulse forming network (PFM) used to pulse the flashlamp or flashtube. Pulse tails do not affect reliability, and the maximum value of  $T$  is 100 microseconds for any truncated pulse width exceeding 100 microseconds. For shorter duration pulses, pulse width is to be measured at 10 percent of the maximum current amplitude.

$\pi_{COOL}$  is the cooling factor due to various cooling media immediately surrounding the flashlamp or flashtube.

Cooling Media	$\pi_{COOL}$
Gas, Air	1.0
Gas, Inert	1.0
Liquid, Deionized Water	0.1
Liquid, Water-Glycol	0.1
Liquid, Fluorocarbon	0.1

Note: Typical values for Xenon flashlamps in military Nd:YAG range-finders and designators are  $E_j = 40$  joules,  $d = 4$  millimeters,  $L = 2$  inches, and  $T = 100$  microseconds. The repetition rate ranges from 1 to 20 pps, and the lamps are normally liquid cooled.

FIGURE D-7. DETERMINATION OF  $\lambda_{\text{PUMP}}$  FOR KRYPTON FLASHLAMPS  
HOURS

$$\lambda_{\text{PUMP}} = (625) \left( 10^{(0.9 - \frac{P}{L})} \right) (\pi_{\text{COOL}})$$

;      ↓  
HOURS      ↓  
KRYPTON

$\lambda_{\text{PUMP}}$  HOURS KRYPTON is the failure rate contribution of the krypton flashlamp or flashtube in failures/million operating hours. The flashlamps evaluated herein are the continuous wave (CW) type and are most widely used for commercial solid state applications. They are approximately 7mm in diameter and 5 to 6 inches long. Average power is typically 4 KW.

P is the average input power in kilowatts, and its value is determined from the actual design parameter for the flashlamp utilized.

L is the flashlamp or flashtube arc length in inches, and its value is determined from the actual design parameter of the flashlamp utilized.

$\pi_{\text{COOL}}$  is the cooling factor due to various cooling media immediately surrounding the flashlamp or flashtube.

Cooling Media	$\pi_{\text{COOL}}$
Gas, Air	1.0
Gas, Inert	1.0
Liquid, Deionized Water	0.1
Liquid, Water-Glycol	0.1
Liquid, Fluorocarbon	0.1

**APPENDIX E**  
**ENVIRONMENTAL FACTORS**

**E.1 Environmental Factors**

The environmental factors are in the form of K-factors. The ground, fixed non-operating failure rate is the base failure rate and can be multiplied by the appropriate environmental factor to estimate the failure rate for the specific environment.

These modifiers are based on MIL-HDBK-217B data.

## ENVIRONMENTAL DESCRIPTION

<u>Environment</u>	<u>Nominal Environmental Conditions</u>
Ground, Benign (G <sub>B</sub> )	Nearly zero environmental stress with optimum engineering operation and maintenance.
Space, Flight (S <sub>F</sub> )	Earth orbital. Approaches Ground, Benign conditions without access for maintenance. Vehicle neither under powered flight nor in atmospheric re-entry.
Ground, Fixed (G <sub>F</sub> )	Conditions less than ideal to include installation in permanent racks with adequate cooling air, maintenance by military personnel and possible installation in unheated buildings.
Ground, Mobile (G <sub>M</sub> ) (and Portable)	Conditions more severe than those for Ground, Fixed, mostly for vibration and shock. Cooling air supply may also be more limited, and maintenance less uniform.
Naval, Sheltered (N <sub>S</sub> )	Surface ship conditions similar to Ground, Fixed, subject to occasional high shock and vibration.
Naval, Un- sheltered (N <sub>U</sub> )	Nominal surface shipborne conditions but with repetitive high levels of shock and vibration.
Airborne, Inhabited (A <sub>I</sub> )	Typical cockpit conditions without environmental extremes of pressure, temperature, shock and vibration.
Airborne, Uninhabited (A <sub>U</sub> )	Bomb-bay, tail, or wing installations where extreme pressure, temperature, and vibration cycling may be aggravated by contamination from oil, hydraulic fluid, and engine exhaust. Classes I and Ia equipment of MIL-E-5400 should not be used in this environment.
Missile, Launch (M <sub>L</sub> )	Severe conditions of noise, vibration, and other environments related to missile launch, and space vehicle boost into orbit, vehicle re-entry and landing by parachute. Conditions may also apply to installation near main rocket engines during launch operations.

ENVIRONMENTAL FACTORS

Applicability

		G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>
All Microelectronics	CLASS C	0.2	0.2	1.0	4.0	4.0	4.0	6.0	5.0	10.0
	CLASS B	0.2	0.2	1.0	4.0	4.0	4.0	6.0	5.0	10.0

ENVIRONMENTAL FACTORS

		G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>
All Semi-conductors except Microwave	JAN	0.2	0.2	1.0	5.0	5.0	5.0	5.0	8.0	8.0
	JANTX	0.2	0.2	1.0	5.0	5.0	5.0	5.0	8.0	8.0

ENVIRONMENTAL FACTORS

		G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>
Microwave Semiconductors	JAN	0.1	0.1	1.0	5.0	5.0	5.0	5.0	8.0	20.0
	JANTX	0.1	0.1	1.0	5.0	5.0	5.0	5.0	8.0	20.0

ENVIRONMENTAL FACTORS

		G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>
All Vacuum Tubes	MIL-STD	0.5	0.5	1.0	6.5	6.5	10.0	10.0	10.0	80.0

ENVIRONMENTAL FACTORS

		G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>
Resistors, Fixed Composition	MIL-STD	0.5	0.5	1.0	2.0	2.5	3.5	3.8	4.0	7.5
	HI-REL	0.5	0.5	1.0	2.0	2.5	3.5	3.8	4.0	7.5

### ENVIRONMENTAL FACTORS

#### Applicability

		<u>G<sub>B</sub></u>	<u>S<sub>F</sub></u>	<u>G<sub>F</sub></u>	<u>A<sub>I</sub></u>	<u>N<sub>S</sub></u>	<u>G<sub>M</sub></u>	<u>N<sub>U</sub></u>	<u>A<sub>U</sub></u>	<u>M<sub>L</sub></u>
Resistors,										
Fixed Film,	MIL-STD	0.2	0.2	1.0	1.3	1.6	2.4	2.8	3.0	7.0
MIL-R-39017	HI-REL	0.2	0.2	1.0	1.3	1.6	2.4	2.8	3.0	7.0
MIL-R-22684										

### ENVIRONMENTAL FACTORS

		<u>G<sub>B</sub></u>	<u>S<sub>F</sub></u>	<u>G<sub>F</sub></u>	<u>A<sub>I</sub></u>	<u>N<sub>S</sub></u>	<u>G<sub>M</sub></u>	<u>N<sub>U</sub></u>	<u>A<sub>U</sub></u>	<u>M<sub>L</sub></u>
Resistors,										
Fixed Film,	MIL-STD	0.4	0.4	1.0	2.0	3.0	4.0	4.4	4.8	7.2
MIL-R-55182	HI-REL	0.4	0.4	1.0	2.0	3.0	4.0	4.4	4.8	7.2
MIL-R-10509										

### ENVIRONMENTAL FACTORS

		<u>G<sub>B</sub></u>	<u>S<sub>F</sub></u>	<u>G<sub>F</sub></u>	<u>A<sub>I</sub></u>	<u>N<sub>S</sub></u>	<u>G<sub>M</sub></u>	<u>N<sub>U</sub></u>	<u>A<sub>U</sub></u>	<u>M<sub>L</sub></u>
Resistors,										
Power Film,	MIL-STD	0.2	0.2	1.0	1.3	1.5	2.4	2.7	3.0	7.0
MIL-R-11804	HI-REL	0.2	0.2	1.0	1.3	1.5	2.4	2.7	3.0	7.0

### ENVIRONMENTAL FACTORS

		<u>G<sub>B</sub></u>	<u>S<sub>F</sub></u>	<u>G<sub>F</sub></u>	<u>A<sub>I</sub></u>	<u>N<sub>S</sub></u>	<u>G<sub>M</sub></u>	<u>N<sub>U</sub></u>	<u>A<sub>U</sub></u>	<u>M<sub>L</sub></u>
Resistors,										
Fixed, Wirewound	MIL-STD	0.2	0.2	1.0	2.5	3.0	3.3	3.8	5.0	11.7
MIL-R-39005	HI-REL	0.2	0.2	1.0	2.5	3.0	3.3	3.8	5.0	11.7
MIL-R-93										

### ENVIRONMENTAL FACTORS

		<u>G<sub>B</sub></u>	<u>S<sub>F</sub></u>	<u>G<sub>F</sub></u>	<u>A<sub>I</sub></u>	<u>N<sub>S</sub></u>	<u>G<sub>M</sub></u>	<u>N<sub>U</sub></u>	<u>A<sub>U</sub></u>	<u>M<sub>L</sub></u>
Resistors,										
Fixed Wirewound,	MIL-STD	0.3	0.3	1.0	2.0	2.3	3.3	3.7	4.0	10.0
MIL-R-39007	HI-REL	0.3	0.3	1.0	2.0	2.3	3.3	3.7	4.0	10.0
MIL-R-26										
MIL-R-39009										
MIL-R-18546										

ENVIRONMENTAL FACTORS

Applicability

Thermistor MIL-T-23648		G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>
	BEAD	0.2	0.2	1.0	2.5	3.0	5.0	4.0	3.4	12.0
	DISK	0.2	0.2	1.0	2.5	3.0	5.0	4.0	3.4	12.0

ENVIRONMENTAL FACTORS

Resistors,  
Variable,  
Wirewound

MIL-R-39015  
MIL-R-27208

		G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>U</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>
	MIL-STD	0.3	0.3	1.0	2.0	2.3	2.7	3.3	4.0	20.0
	HI-REL	0.3	0.3	1.0	2.0	2.3	2.7	3.3	4.0	20.0

ENVIRONMENTAL FACTORS

Resistors,  
Precision,  
Wirewound

Potentiometer  
MIL-R-12934

		G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>U</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>
	MIL-STD	0.2	0.2	1.0	2.0	2.0	2.0	2.4	3.0	5.0
	HI-REL	0.2	0.2	1.0	2.0	2.0	2.0	2.4	3.0	5.0

ENVIRONMENTAL FACTORS

Resistors, Semi-  
precision, WW

Potentiometer  
MIL-R-19

MIL-R-39002  
WW Power

Potentiometer  
MIL-R-22

		G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>U</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>
	MIL-STD	0.2	-	1.0	2.5	3.0	3.3	-	-	-
	HI-REL	0.2	-	1.0	2.5	3.0	3.3	-	-	-

ENVIRONMENTAL FACTORS

Resistors,  
Variable Non-

Wirewound  
Trimmers

MIL-R-22097

		G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>U</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>
	MIL-STD	0.3	-	1.0	2.0	2.7	3.3	4.2	5.0	26.7
	HI-REL	0.3	-	1.0	2.0	2.7	3.3	4.2	5.0	26.7

ENVIRONMENTAL FACTORS

Resistors,  
Composition  
(Low Precision)

Potentiometer  
MIL-R-94

		G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>U</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>
	MIL-STD	0.1	-	1.0	5.0	5.0	5.0	5.5	6.0	10.0
	HI-REL	0.1	-	1.0	5.0	5.0	5.0	5.5	6.0	10.0

**ENVIRONMENTAL FACTORS**

**Applicability**

Capacitors, Paper & Plastic Film MIL-C-39022 MIL-C-14157 MIL-C-19978	MIL-STD	G <u>B</u>	S <u>F</u>	G <u>F</u>	A <u>I</u>	N <u>S</u>	G <u>M</u>	N <u>U</u>	A <u>U</u>	M <u>L</u>
		0.5	0.5	1.0	2.0	2.0	2.0	4.5	7.5	10.0
HI-REL		0.5	0.5	1.0	2.0	2.0	2.0	4.5	7.5	10.0

**ENVIRONMENTAL FACTORS**

Capacitors, Mica MIL-C-39001 MIL-C-5	MIL-STD	G <u>B</u>	S <u>F</u>	G <u>F</u>	A <u>I</u>	N <u>S</u>	G <u>M</u>	N <u>U</u>	A <u>U</u>	M <u>L</u>
		0.3	0.3	1.0	1.5	1.5	1.5	1.5	3.5	6.0
HI-REL		0.3	0.3	1.0	1.5	1.5	1.5	3.5	6.0	7.5

**ENVIRONMENTAL FACTORS**

Capacitors, Mica MIL-C-10950	MIL-STD	G <u>B</u>	S <u>F</u>	G <u>F</u>	A <u>I</u>	N <u>S</u>	G <u>M</u>	N <u>U</u>	A <u>U</u>	M <u>L</u>	
		0.3	0.3	1.0	1.5	1.5	1.5	1.5	4.4	6.0	7.5
HI-REL		0.3	0.3	1.0	1.5	1.5	1.5	1.5	4.4	6.0	7.5

**ENVIRONMENTAL FACTORS**

Capacitors, Glass MIL-C-23269	MIL-STD	G <u>B</u>	S <u>F</u>	G <u>F</u>	A <u>I</u>	N <u>S</u>	G <u>M</u>	N <u>U</u>	A <u>U</u>	M <u>L</u>	
		0.3	0.3	1.0	1.5	1.5	1.5	1.5	3.5	6.0	7.5
HI-REL		0.3	0.3	1.0	1.5	1.5	1.5	1.5	3.5	6.0	7.5

**ENVIRONMENTAL FACTORS**

Capacitors, Ceramic MIL-C-11015 MIL-C-39014	MIL-STD	G <u>B</u>	S <u>F</u>	G <u>F</u>	A <u>I</u>	N <u>S</u>	G <u>M</u>	N <u>U</u>	A <u>U</u>	M <u>L</u>	
		0.5	0.5	1.0	2.0	2.0	2.0	2.0	4.0	5.5	7.5
HI-REL		0.5	0.5	1.0	2.0	2.0	2.0	2.0	4.0	5.5	7.5

**ENVIRONMENTAL FACTORS**

Capacitors, Tantalum Electrolytic (Solid) MIL-C-39003	MIL-STD	G <u>B</u>	S <u>F</u>	G <u>F</u>	A <u>I</u>	N <u>S</u>	G <u>M</u>	N <u>U</u>	A <u>U</u>	M <u>L</u>	
		0.5	0.5	1.0	2.0	2.0	2.0	2.0	4.5	7.5	10.0
HI-REL		0.5	0.5	1.0	2.0	2.0	2.0	2.0	4.5	7.5	10.0

**ENVIRONMENTAL FACTORS**

Capacitors, Tantalum Electrolytic (Non-Solid) MIL-C-39006 MIL-C-3965	MIL-STD	G <u>B</u>	S <u>F</u>	G <u>F</u>	A <u>I</u>	N <u>S</u>	G <u>M</u>	N <u>U</u>	A <u>U</u>	M <u>L</u>	
		0.5	0.5	1.0	3.0	3.0	3.0	3.0	7.0	10.0	15.0
HI-REL		0.5	0.5	1.0	3.0	3.0	3.0	3.0	7.0	10.0	15.0

ENVIRONMENTAL FACTORS

Applicability

Capacitors,  
Aluminum Oxide  
MIL-C-39018  
Aluminum Dry  
Electrolytic  
MIL-C-62

		G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>
	MIL-STD	0.5	0.5	1.0	6.0	6.0	6.0	10.0	15.0	20.0

ENVIRONMENTAL FACTORS

Capacitors,  
Variable,  
Ceramic  
MIL-C-81

		G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>
	MIL-STD	0.3	-	1.0	2.0	2.0	2.0	6.0	12.5	17.5

ENVIRONMENTAL FACTORS

Capacitors,  
Variable,  
Piston Type  
MIL-C-14409

		G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>
	MIL-STD	0.3	0.3	1.0	3.0	3.0	3.0	16.7	26.7	40.0

ENVIRONMENTAL FACTORS

All  
Inductive  
Devices

		G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>
	L-STD	0.5	0.5	1.0	2.5	2.5	1.5	2.5	3.5	5.0
	HI-REL	0.5	0.5	1.0	2.5	2.5	1.5	2.5	3.5	5.0

ENVIRONMENTAL FACTORS

Lasers

		G <sub>B</sub>	S <sub>F</sub>	G <sub>F</sub>	A <sub>I</sub>	N <sub>S</sub>	G <sub>M</sub>	N <sub>U</sub>	A <sub>U</sub>	M <sub>L</sub>
		0.2	0.2	1.0	5.	5.	5.	5.	8.	8.